PRINCIPLES OF HYGIENE

FOR

THE SCHOOL AND THE HOME

TOGETHER WITH

SO MUCH OF ANATOMY AND PHYSIOLOGY AS IS NECESSARY TO THE CORRECT TEACHING OF THE SUBJECT

BY

EZRA M. HUNT, A.M., M.D., Sc.D.

TENTH PRESIDENT OF THE AMERICAN PUBLIC HEALTH ASSOCIATION, SECRETARY OF THE STATE BOARD OF HEALTH OF NEW JERSEY, AND INSTRUCTOR IN HYGIENE IN THE NEW JERSEY STATE NORMAL SCHOOL

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PREFACE.

THE design of this book is to furnish a Manual of Hygiene for use as a school text-book, and one that will be of service to all those who would acquaint themselves with the principles and practice of right living. When the study of the physical man was first urged upon the attention of educators, it was with the special view of an acquaintance with Anatomy and Physiology. Hence most of the books which have been written cling to this title, and, while recognizing Hygiene as important, treat it as subsidiary.

The author has been impressed with the view that, for the average scholar, a knowledge of Hygiene is far more important than that of human structure and organs, and that the present courses of study justify the teaching of these to children only to the degree necessary for an intelligent **practice** of the health-preserving art. While this involves a valuable general knowledge of the **human system** and its functions, it also involves an equally important inquiry into our relations with our **surroundings.**

It has been my design to furnish an outline which will acquaint the student with the scope of the study, and impart information that will meet his practical and every-day needs. For the teacher, I have desired to present a basis or nucleus for a much fuller presentation of details than can be included within the scope of a single volume. In my own teaching, I have always found it necessary to use far more than any one text-book contains, or ought to contain. Any teacher who will accept this as a guide, and avail himself

of the additional information to be derived from Physics, Chemistry, Geology, etc., and from the abundant literature of the subject, cannot fail to make the study of Hygiene as interesting as it is essential.

I have not been obliged to use any human bones or objectionable plates in the school-room. The skeleton of a kid, and a few bones from the table, have answered every purpose. The relations of earth, air, water, foods, etc., are easily illustrated by experiments with ordinary school apparatus.

While the author has not attempted to limit this book to the teaching of the injurious effects of **stimulants** and **narcotics** in the treatment of these subjects, in their proper connection, he has not failed to state the entire truth, and has been particular to give no doubtful views. It is believed that students will see that these subjects are treated because the facts concerning them are unmistakable, and their connection with health inevitable, and that they will be impressed more by the facts thus presented than by any special pleading.

In the preparation of this volume I have freely consulted all the most recent authorities, and I am especially indebted to the works of Huxley, Angell, and Newsholme.

For many valuable suggestions, and for aid in press-reading and criticism, I am greatly indebted to the Hon. E. O. Chapman, State Superintendent of Public Instruction of New Jersey.

EZRA M. HUNT.

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HYGIENE.

CHAPTER I.

INTRODUCTORY OUTLINE OF THE SUBJECT.

THE design of this manual is to teach the science and the art of Health. Science is the exhibition of the actual relations of facts and principles and their bearing upon one another. It is not a mere knowledge of facts, but is the result of their classification and relationship. It is such an interpretation of facts having an ascertained, natural relation to each other as enables us to deduce from them laws. If there are such fixed laws which determine whether we shall be in good health or poor health, or have short or long lives, and if we can ascertain these laws, we can have a science as to the physical constitution and welfare of man as definite as we have about the physical constitution of the earth. If so, there is a science of Health. It is called ***Hygiology.***

2. Art is the application of the facts and principles of science,—a system which admits of the employment of distinct methods and rules. It is **applied** science. Sometimes the application or practice precedes a knowledge of the science. If so, it is afterwards found to be in accord with classified facts and with certain laws. If in

accord with definite rules we are able to preserve health and to prolong life, we each have an art to practice which has as its income and reward great personal benefits. It is the art of Health. It is named ***Hygiene.***

This term is derived from a Greek word meaning **To be in good health.**

3. In ancient times the Greeks had a temple, dedicated to a goddess called Hygiea, at which votive offerings were made in order to secure health. In more modern times there have been those who have looked upon sickness as in such a sense a providential dispensation as to carry it out of the sphere of physical law into that of special infliction. But the more we come to know of variations from a condition of health, the more do we find them to be the providential penalty of broken law on the part of ourselves or of our ancestors. The more, also, do we find as to the possibilities of bettering our own health and that of others, by finding out just what the laws of nature and the applications of art indicate, and then conforming to these indications. The tendency to spring back to the condition of health is so strongly implanted by God in the human constitution, that it long ago led Hippocrates to speak of the *vis medicatrix naturæ*, or the restorative force of nature.

4. The name of **physician** is derived from the Greek word *φύσις*, meaning nature, because the care of the human life and health was accounted to be the first and most important study of nature. Strange to say, the physical sciences for a time seemed to ignore man's place in nature, and astronomy, geology, botany, and other studies of external nature seemed to claim a higher place than the study of the nature of man. Yet this

study is more vital to his welfare than any other, and is excelled by none other in the wonders of science and the possibilities of art which it unfolds. In its breadth it includes all that is meant by right living, since the physical, intellectual, and moral natures are so united as to be very interdependent. While we now have to do primarily with the physical and material substance, and the laws of its structure and functions, we cannot lose sight of this unity. Since man is a part of nature, and since he is himself a complex piece of mechanism with various organs and functions, it is necessary to define a few terms which relate to him and to his surroundings.

5. A study of life in its extent, and as applicable to all living things, is known as the science of ***Biology,*** or a knowledge of the **Laws of Being**. So far as it has to do with human structure, it is called the science or study of **Human Anatomy.** A knowledge of this comes only from a minute examination and description of all the parts that make up the structure. It also includes an inquiry into the laws of structure. To different parts of this study different names are given.

So far as it has to do with *function*, or with the mode in which our structure or organs operate, it is called **Human Physiology.** A knowledge of this comes in part from a study of structure, in part from experiment, and still more from observation and experience as to how these functions are performed, and the conditions which in any wise aid, modify, or embarrass them.

6. The science and the art of Hygiene consist in knowing how best to secure the intended exercise of function, to furnish such aids as nature indicates, and to prevent such embarrassments as tend to permanent impairment.

It is also called *Sanitary Science*, or the art of *Sanitation*, from the Latin word for soundness. As an engineer may operate an engine without knowing all the details of its construction, or without knowing all that there is to be known about steam, so success in the art of Hygiene, or in teaching or practicing it, does not necessitate a complete knowledge of all the organs and the functions of the whole body.

7. While some knowledge of each of these is essential, and is to be sought in any attempt to acquire a knowledge of Hygiene, it is possible to know very much of both of these branches of study, without any valuable, practical acquaintance with the art of securing or preserving health. While for their special study every argument can be adduced that applies to the study of physical nature in the world about us, for our purposes they are *related* studies, to be pursued only to the degree which is essential to an intelligent appreciation and application of the art of securing health.

8. We are, also, to bear in mind that to this study there are other cognate sciences, some acquaintance with which is necessary in the practical application of the principles of Hygiene. Thus some knowledge of **Pathology**, or the condition and action of parts or organs in a state of disease, often throws much light on normal function and the modes of promoting it.

As **physical, mechanical,** and **chemical** laws are involved in vital processes, some knowledge and appreciation of these is necessary. Hence it is, that various facts that relate to matter, force, motion, heat, and all life, have the most intimate relation to our subject. While experience has long furnished glimpses of the truth, it was

impossible for Hygiene to have a scientific basis, and to be taught and practiced as an art, until various physical sciences had made progress. As it now is, we are able to secure aid from all these, and to deduce laws which have a direct bearing on the appreciation and prolongation of life and the avoidance of disease.

It is thus found that Hygiene is an aggregation of valuable parts of various sciences which bear much on life. It is a mosaic, all the more valuable because formed of so many parts, since they admit of exquisite adaptation and adjustment to the art of preserving life. Thus mechanics, chemistry, geology, botany, and various other physical sciences, are constantly furnishing additions to this science and art.

9. Nor has it to do with the **physical** sciences alone. Taking the word **Hygiene** in the largest sense, it signifies rules for perfect culture of mind and body. It is impossible to dissociate the two. The body is affected by every mental and moral action; the mind is profoundly influenced by bodily conditions. While we do not need to confound the material and the spiritual, we do need to recognize their relations, and that there are laws of healthy action which apply to each. The body becomes the soil into which the mind and the spirit are implanted, and from which, if properly exercised, they must draw much of the source of their power in this world. Hence, even **Psychology**, or a description of the operations of the mind, on the basis of careful and classified observation, is in some of its aspects not foreign to our inquiry. So it has been claimed that the knowledge of the philosopher in all his departments has an intimate bearing on this care of life. The pioneer of modern Hygiene entitled his

first work the Philosophy of Health, and in it treated of all these departments. As philosophy is an inquiry into facts and principles and an attempt to weigh or appreciate their real value, and as there is no value superior to that of perfect health for body, mind, and soul, the term was rightly applied. Hence in our own language, health is not only the generic term of wealth, welfare, etc., but its possession is the fullest conception of earthly bliss.

10. In its study we can constantly perceive, in the harmonious proportions and complete balance of all parts, the evidence of the designing skill of one great Creator. Even amid the disorder which has only resulted from disobedience of law, we cannot but admire the wonderful reparative processes and the constant struggle which this physical structure seems to make to resume its original perfectness. As we examine into the exquisite adaptation of the thousands of parts of the body to each other, we can no more conceive of the absence of a maker than we can conceive of thousands of types falling into words and sentences without a presiding and designing power.

11. As we behold the reign of law, and the uniformity of result, if the laws of health and life are obeyed, we are able to see that the vast amount of suffering and incapacity in the world is the result of breach of law for which ignorance and sin are alone responsible. As we see how reparative and conservative of health this wonderful organism is, how self-regulating and self-repairing it is, if only we approach to conformity to its laws of being, we come to admire the wondrous mechanism and plan, and gain courage in the effort to make our lives what they should be. There is a confidence of success, when

we learn that these laws of life and health are ascertainable, and that in conformity thereto results for our own enjoyment and usefulness are as certain as in any of the laws relative to the physical world about us.

12. Such progress has been made in our knowledge of the laws of life, that Parkes has well said that "it is undoubtedly true that we can even now literally choose between health and disease, — not perhaps always individually, for the sins of our fathers may be visited upon us, or the customs of our life and the chains of our civilization and social customs may gall us, or even our fellowmen may deny us health, or the knowledge which leads to health. But, even with these embarrassments, it is remarkable how far we can improve or correct these conditions, and how much we may profit individually by the knowledge and practice of the laws of our being."

13. Because this practice needs to begin very early in life, because habits formed are so likely to become fixed, and because knowledge and impressions early received are the most lasting, the study of Hygiene ought not to be left for mature life. It needs to form a part of the home and school instruction and training. What we would have appear in individual and social and natural life we must have appear in the home and in the school; especially when it has to do with our growth and development, and when the knowledge is needed as much in early life as it is afterward. It is essential, in order that full development may be secured and a general condition of health maintained.

This acquaintance with the sanitary demands of our natures, and with the modes of securing for the body what its construction and functions require, enables us

to avoid many errors, and to give to it the advantages to which it is entitled.

14. Here are some of the reasons for the study, and for the early study, of Hygiene, which can be enlarged upon and illustrated by the teacher, or by any one who will consider the subject in its intimate bearing upon life.

(*a*) Good health is intimately related to our success and happiness in life. The impediments and limitations which sickness or partial invalidity impose, and the anxiety and unrest they occasion, are too often well known.

(*b*) Education is physical, intellectual, and moral. Any attempt to deal exclusively with the development of one part of our nature without the other is as wrong in practice as it is in theory.

(*c*) Knowledge of how to care for and develop the physical power is no more natural than much of our knowledge as to mind or morals. Teaching and training are as essential in the one as in the other.

(*d*) Habit teaching in all its varieties is very much the intent and the accomplishment of education. This, at first, is mainly made up of physical acts, the mind itself receiving its impressions through physical methods. All through life the acquirement of physical habits is the key of self-control, self-reliance, and to that educational attainment which helps to ability and character.

(*e*) In physical teaching and training very much is accomplished for discipline, for method, for observation, experiment, memory, and thought.

(*f*) Man's place in nature is larger than that of any other one thing in it. A study of him is a study of

nature and of one of the natural sciences and the mode of teaching it.

(*g*) There is much training of the moral nature in physical education. Behavior is having the being in possession and under control, and the knowing how to handle one's self as a whole. Obedience to the knowledge so acquired is an element alike of character, conduct, and power.

(*h*) It aids the teacher much in his own preparation for his work and in his discipline.

(*i*) We are constantly seeing the evils of that kind of education which concentrates too much on mere mental development. Consult Froebel, Horace Mann, Canon Kingsley, etc.

(*j*) The need of it has become largely recognized elsewhere. We have examples in Sweden, France, and England, and in some of our own states and cities.

15. This study naturally divides itself into five departments.

I. There must be such a knowledge of the structure and functions of the human body as will enable us to know what are the conditions of its normal being, or what it requires. By a study, for instance, of bones and of muscles, of the lungs and their mode of action, or of the digestive apparatus, we cannot fail to arrive at some correct conclusion as to how they are to be used and as to the relations of exercise, of air, and of foods thereto.

II. As the human system derives its supplies from without, and is dependent upon its surroundings, we need to know precisely what these supplies are, and what surroundings are conducive to health, as well as to know what are hazardous thereto or positively injurious.

Thus our relations to the earth, to the air, to water, to foods, to heat and light and moisture, to odors, to sensations and impressions made on the senses, — indeed, to most of external nature, — is such that we have carefully to consider how these favorably or unfavorably affect human life.

III. When we find actual defects, the practical application of Hygiene often requires that we should know how to adapt our methods to the defects so as to secure a return to the normal conditions, and cause complete recovery. Here our effort is not merely to make up for the defect, but so to deal with it as by gradual improvement to remove it. Both physical and mental hygiene are sometimes able, by pliable and gradual methods, to secure return of health, where the abrupt application of the laws of health, as applicable to perfect functions, would produce only disease. Thus a weakened muscle may not need such exercise as that muscle at such an age ought to be able to endure, but such as is suited to its reduced capacity, and so arranged as to restore it to its proper strength.

IV. Since, when we find defects in our construction or functions, and defects in our environment or surroundings which have a bearing on our well-being, we cannot always be rid of them, we often need to inquire by what methods adjustments are to be made and such compensation secured as will reduce the evil to a minimum. Thus houses and clothing and fires serve to adjust us to the outside world in some respects. If the upper teeth are gone, we may not only fulfil an indication as to digestion by an artificial set, but help to preserve those in the lower jaw by providing a co-operating set.

V. In addition to these we need to have a correct view of our social and corporate relations as members of community and of the obligations we are under to preserve our own health and that of our neighbors. Hence it is proper to speak of personal hygiene as having to do with (*a*) our personal health, as it relates to ourselves; (*b*) our personal health, as it relates to the welfare of our neighbor; and (*c*) public health, as it relates to the family, the school, the municipality, the state, or the nation.

While all these divisions cannot be fully treated in such a manual as this, it is desirable to recognize the **breadth** of the study, as thus we are likely to be more eager in its pursuit, and to prepare for more extended insight. Since we more readily see and understand nature as it surrounds us, than as it is within us, it will be the more convenient order to consider first our **surroundings,** as they are related to our health.

CHAPTER II.

THE EARTH AS RELATED TO HUMAN HEALTH.

AS the **earth** is by nature fitted for the **habitation** of **man,** we expect to find it adapted thereto, just as we find the air suited for breathing. Yet the earth, like the air, has undergone very many changes, and may not now in every place and under every circumstance be suited for human dwelling. It is just as sensible to talk of changing ground as of changing air for health.

2. The **ground** may have become so submerged by water, or so filled with it quite up to the surface, as to make it too damp or wet for a being not meant to be aquatic. It may have become so shut out from the sun as not to be able to dispose of that amount of water near the surface which, under natural circumstances, it is advantageous to have circulating or evaporating there.

The soil or ground nearest the surface may be so overcharged with decaying or putrescible matter, that none of the usual processes of nature can dispose of it, and so there will be a pollution of the adjacent air, earth, or water. If so, it becomes unfriendly to man's physical welfare.

3. The ground or earth represents at least five constituents, all of which are related to health. It has its inorganic or **mineral constituents,** which may exist in the form of rock or be mingled with the softer materials of ground. These are such as fire will not consume. Many

of these are entirely harmless, or useful as ores, or as giving solidity to the earth's surface, while others, if they become diffused in fine particles through the air, or come to be dissolved and suspended in water, have an influence upon health. Thus finely pulverized dust may be irritating, or the water, as in limestone regions, may become impregnated with lime so as to produce hard water, which as a rule is not as healthful as the softer water. Some of these inorganic constituents, like the ore of arsenic, are directly poisonous.

4. Next, the earth has both living and dead matter in various forms of **animal and vegetable life.** This, so long as it is alive, or so long as, in its processes of growth and decay, it is being appropriated by animals or plants to which it is suited, is not injurious. But so soon as there is such accumulation as is not thus appropriated, or such as is beyond the ordinary demands of vegetation, or where it is gathered with no growing vegetation to consume it, it becomes a menace to health, and must be studied in its relation thereto. The very richness of ground, which is so favorable to most plants, is likely to be hurtful to human life, if the soil is exposed to the heat of the sun, and has no chance to give up its riches to the plant-life for which it was intended.

5. Next, the ground contains **air** or the constituents of air. Air is intended to circulate in the upper ground as well as above it. It is by its free circulation that the ground disposes of various organic and decayable matters in it, and allows these to be taken up by animals or by growing plants. All the multitudes of little spaces between the particles of ground are filled up either by water or by air, which alternately circulate in it. If you fill

a cup with soil, you may yet pour into it considerable water, which, as we say, soaks into the ground. This merely means that it occupies the spaces between the particles of earth which just before had been filled with air.

While there are some other gaseous substances to be found in the ground besides the nitrogen and the oxygen which form common air, these are but small compared with the vast amount of air which the ground contains. It is often from thirty to fifty per cent, and in loose surface soil may even equal its own volume. This capacity of the ground for air is also a measure of its capacity to contain the various gaseous products of decomposition, which may be set free, and which not only make foul the ground, but the air also. If ground is polluted, foul gases in part take the place of pure ground-air. Health and life greatly depend upon the fact that air or water are not stagnant in the ground just beneath us, but are constantly circulating and conducting those changes which are favorable both to animal and vegetable life. It is one of the evils of wet ground, that it expels the air, and so prevents evaporation and circulation as to keep the ground soaked. This prevents those changes in organic or decayable substances which are necessary to enable them to be taken up by grains, vegetables, and grasses. So we are to remember that air belongs in the ground. In its circulation, it is meant to oxidize and hydrocarbonize animal and vegetable decay, so as to make it innocuous, and furnish great volumes of carbonic acid to vegetable life.

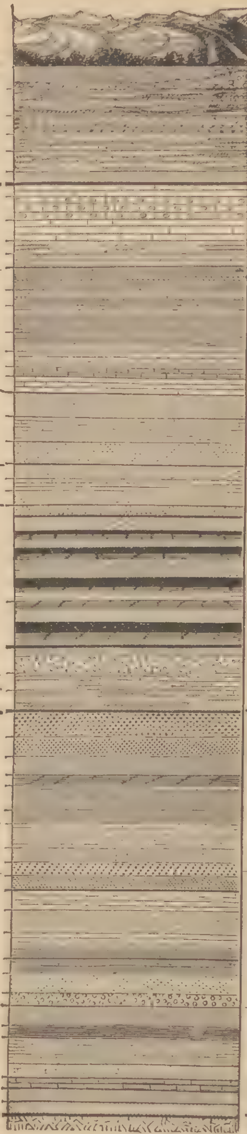
6. **Water,** as we have already incidentally seen, has a very important relation to the earth. It is not only

that the earth is to be the receptacle of the water as it comes from the clouds, which, by its percolation through the soil, carries on various processes. There is a depth, varying with soil and locality, at which the **ground water** is intended to **fill up** the spaces between the earth particles. It can thus be drawn upon for the supply of the earth vegetation, or by reason of its relation to strata and water-sheds it flows out upon the surface in ponds, lakes, and rivers, and is accessible by means of wells, so as to furnish drink to man and to beast. When it is stagnant too near the surface, it aids to convert organic matter into peat; but when it is found as a kind of permanent reservoir far beneath the surface, it is there stored for use, only subject to slight fluctuation, and kept in better condition than by any storage art of man. We shall in another chapter consider it as a drink. Suffice it here to refer to (*a*) its important relation as a part of the earth in deciding as to conditions of decay, (*b*) in affecting temperature by its evaporation, and (*c*) in the dampness and ill-health it so often produces when stagnant or too constantly abounding near the surface.

The chief design of **drainage** in its health-relations is to secure for the upper ground free circulation both of air and of water, and to drain off water from the soil.

7. We next note that the **sun** and **temperature** have much to do with the ground. It is intended to have its alternations of heat and of cold. The sun causes in the earth a diurnal wave of heat, in our climate, of about four feet in depth, varied somewhat by soils and seasons. As this recedes by night there is circulation of heat beneath the surface; the line of **uniformity of temperature** is from fifty-seven to ninety-nine feet below the surface. Ground

GEOLOGICAL SECTION. — The Different Formations and their Equivalent Soils.



	Post Tertiary.	Alluvial Soils.
	Tertiary.	Oak Land Soils. Pine Land Soils.
MESOZOIC.	Cretaceous.	Upper Marl Bed. Middle Marl Bed. Lower Marl Bed.
	Jurassic.	Clay Marl. Clay and Sand Soils. Red Sandstone.
	Triassic.	Shale and Trap Soils.
CABONIFEROUS.	Permian.	Sandstone and Shale Soils.
	Coal-Measures.	Limestone Soils. Clays. Sandstone Soils.
	Sub-Carboniferous.	Limestone Soils.
	Devonian. Old Red Sandstone.	Limestone Soils. Slaty Soils.
	Upper Silurian.	Limestone. Sandstone. Conglomerate Soils.
	Lower Silurian.	Slate. Limestone. Sandstone Soils.
	Archæan.	Gneissic Soils.

may be kept so continuously cold as to be made damp thereby, or so continuously and excessively hot as that the decaying material in it is forced into rapidity of change incompatible with the health of human beings. The ancients termed fire, air, earth, and water the elements. Each and all are in the ground beneath us, and have much to do with health.

It is worthy of note how the lower animals come to know the differences of ground conditions, and to choose for rest spots where the ground is dry and airy. These are cases in which the instincts of animals are wiser than the thoughtlessness and ignorance of men.

8. The **earth** differs much in all the respects we have mentioned according to its geological formation, its elevation, its latitude and longitude, its plains or forests, and other variations made by constitution, locality, or plant-growth. All these make or affect the **climate.**

The wide variety there is in geological formation and arrangement needs to be studied and to some degree understood by the sanitarian. These do much in determining the relations of air, water, heat, and decomposition to the ground and to those upon it. A tenacious clay near the surface has made many a locality water-bearing and unhealthy, when the removal of a few feet deeper down would have given a gravel foundation and an extended drainage. The map on the opposite page will serve to show how many different strata there may be. They admit of all varieties of arrangement.

It is, however, with the soil, or the earth within a few feet of the surface, that we have especially to deal when we speak of the earth as related to health. **Soil** is derived from the rock from which the substratum is composed,

mingled with animal and vegetable matter. It crumbles into sand, clay, gravel, etc. So we come to speak of clayey, gravelly, and sandy soils. When there is an abundance of organic matter mingled with it or deposited upon it, as where successive forests have fallen upon it, we call it a **loam.** Where the soil is largely made up from such decay, or the overflow from such deposits, it is known as alluvial soil.

Some soils, instead of being mostly made up of the broken-up rock or strata beneath them, have been formed by drifts or deposits of earth, stones, and loose material, which by winds, rains, and the force of great freshets of moving water or ice have in ages past been dislodged and deposited in valleys, or where they have been caught by some barrier.

9. Between **air** and **water** and **heat** there is a correlation and conservation which is as wonderful below ground as above it. The surface, like the human skin, is but the plane of contact, while within is incessant motion. This condition of relations is necessary for the carrying forward of changes which, when uninterrupted, tend healthward, but which, when suspended, contaminate the ground. There is a *vis medicatrix naturæ* in the earth as well as in man, which is dependent upon the uninterrupted play of natural forces. The effect of stagnant water is to cause the decomposed vegetable and animal matter in the soil to accumulate. The conditions of temperature of air and of liquids are self-regulating to a surprising degree, when art does not intervene. But to this end **there must be air and heat and water circulation.** Even those myriad organisms, from bacteria upward, which science is revealing, are instituted methods for

disposing of organic material; but it is only amid the activities of air and water circulation that their action is manifested. The capacity of the ground for air is readily shown by expelling the air from dried earth. In other words, by pouring into it water we find its capacity for air. Such ground as we are familiar with varies much as to its porosity or dryness; and even marble will hold four per cent of water.

10. The sanitarian is not slow to make inquiry about soil, if he is seeking to determine where is **the best place to live.** He knows that a tenacious, clay soil is not likely to be healthful, unless it can be so drained at the sides or so cut through down into a gravel as to make it dry and more porous. He does not, because a pond is unsightly and a house will cover it, drain off a pond and build a house over it. He knows that the causes which made the pond there, and the long accumulation of organic matter about it, are unfavorable to health. If all his land is like that of a Western prairie, where the muck or alluvial deposit is many feet deep, he seeks to know how far it is to gravel or sand, or how he can drain and improve the soil, or compensate for its too great richness, by other aids to its healthfulness. He would, for instance, see that close to his house the land was heavily cropped each year, and that ashes and lime were added to it in the cropping rather than any organic compost. He would not shade it with trees as he would if building on a light gravelly soil exposed to the sun.

11. It is a rule as to all soils desirable for dwellings, school-houses, or factories, that the **level of the ground water** should be at least three feet below the bottom of the cellar, and that it should not be so affected by

heavy rains as to be subject to rapid or frequent rising. This means a soil where drainage is good, or where air and water and warmth get into the upper soil from above the surface. We not only want to be rid of the water, but equally to have the ground filled with pure air. If the well is near the house, its depth and the rise and fall of its water give indication of the general water level, unless there is some abrupt change of soil near the house.

12. Where the water is too near the surface much can be done by thorough systems of drainage which are now well understood. The building of cellar-walls with hard brick laid in cement, and with the wall cemented on its back surface, with upright spaces between the layers, and with a cement floor, adds much to the dryness. In addition, a course of slate or asphalt or other impervious material is sometimes laid upon the brick just above the surface of the ground. This is called a **damp course,** and is intended to prevent the passage of dampness from the cellar-wall to the walls of the building. Perforated brick and terra-cotta are used for the same purpose, as allowing evaporation, and so securing dryness as well as a material of different compactness. Impure ground-water is often sucked up from one brick to another so as to reach the walls of rooms. Chills and fever, colds, consumption, rheumatism, neuralgia, and other ailments are certainly often traceable to living on too damp earth, or in dwellings that partake of this dampness.

13. Women, who live more in the house than men, are especially liable to suffer in health from cellar or house dampness. Whole districts of country have had their sickness-rates and death-rates sensibly and permanently diminished by systems of drainage. Many cities

need systems of drainage as much as they do systems of sewerage. Even in the putting down of sewers, one of the incidental benefits is that the lines of these sewers break through the layers of soil and provide drain-courses through the ground. Subsoil drainage and surface drainage are needed for many soils, if buildings are to be erected on them. Every home and every schoolhouse needs to be studied in its relation to the earth around it.

CHAPTER III.

WATER IN ITS RELATION TO HEALTH.

WE have had occasion to refer to water in the chapter on EARTH, since it forms so large a portion of the globe on which we live. It is not only that the rivers, the seas, and the ocean form so large a part of it: it abounds also in the soil, and, hidden beneath various strata, it comes to the surface in springs or is sought for by means of wells.

1. Leaving the consideration of its relation to all vegetation and to all varieties of lower animal life, we have still greater occasion to consider it as a **drink**, and as related to the life and health of mankind. It forms so large a portion of the body, that in a person weighing one hundred and forty pounds about one hundred pounds is water. So we have had the modest definition, that man is made up of a little solid material dissolved in six pailfuls of water. Of the **blood**, water constitutes eighty parts, and of the **solid tissue**, about seventy-five. Of all the secretions it is the chief component, so far as actual quantity is concerned.

2. Our **bodies**, on an average, part with over two quarts, or sixty-four ounces, of water each day; and with much more under violent exertion. Of this amount full eighteen ounces passes off through the **skin** and about nine ounces through the **lungs**. Thus **water** is the great distributer of all materials introduced into the system,

and the conveyance by which much of the used-up material passes away from it. While it cannot be said to be a food, in the usual sense, yet it may to some extent be appropriated as nourishment. In extreme cases of lack of food, it serves to bring into use the materials within the system which may, by any possibility, be made available for nutrition. By its evaporation, it equalizes the temperature of the body and assists in chemical changes.

3. All the water used in the body is not derived from what is generally called **potable** or **drinking water.** It forms a part of grains that are usually spoken of as dry. It abounds in meats, vegetables, and fruits. We reckon about thirty-eight per cent of it in bread, seventy per cent in lean meat, from seventy to ninety per cent in vegetables, and even more in some fruits. Indeed, if we used all these in a natural state, there would not be need of very much additional supply. The supply we do need we derive from the earth or from the sky. The great inquiry is how to secure it in the purest and most acceptable form.

4. As a chemical substance, **water** consists of two parts of hydrogen and one of oxygen by volume, or one part of hydrogen and eight parts of oxygen by weight. It is capable of containing much *air* between its particles, and in its natural state always contains it. Because of this some kinds of fish do not need to come to the surface of the water to get their supply of air. A gallon of water at 62° F. weighs ten pounds; at the boiling-point, with the air expelled, it weighs nine and one-half pounds. When air is taken into the stomach unmixed, it sometimes causes much disturbance, while that which gets there mixed with the water or the food is an important **aid to digestion.**

Twenty-five gallons of water contains in its air about five parts of the oxygen and nitrogen of which ordinary air is composed. But while five parts of ordinary air contain nearly four parts of nitrogen and one of oxygen, five parts of the air of water will contain about three parts of nitrogen and two of oxygen.

5. Well **aerated water** holds in solution about two cubic inches of oxygen and six of nitrogen per gallon. Twenty-five gallons of ordinary lake water contains from a quarter to a half pint of carbonic acid gas. River water often contains to every twenty-five gallons one gallon of carbonic acid gas in solution, because the chemistry of nature has been busy in disposing of the carbonaceous or decayable matter in it. Where water in city wells, for instance, is very sparkling, and almost inclined to effervesce, it is a suspicious circumstance; for it shows how busy nature has been in appropriating the organic material, and that it may have failed to dispose of it entirely. Water that is exposed to air fouled with various gases will absorb them and hold them in solution, when the water is stagnant and not abounding in oxygen. Thus water from graveyard wells may often be clear and sparkling, but if kept in a closed, half-filled bottle two or three days will emit odor.

6. The **best water** for drinking or potable purposes is that which is mingled with pure air which is free from any organic animal or vegetable matter, either solid or gaseous, and which does not hold in suspension or solution any mineral matter. Such ideal or chemically pure water is rarely if ever found; but with this as a standard, we can define those departures therefrom which are beyond the bounds of safety.

Water is frequently colored by **vegetable matters,** and yet the amount is such as to be easily neutralized or discharged from the system without evil effects. It is only when vegetable matter is in a state of decay that there is much risk. A good deal of it is disposed of in the ordinary processes of nature, but in very hot or dry weather becomes hazardous. The same is true as to animal matter, or excretions, which are in general more dangerous than vegetable matters. It is chiefly so when undergoing active putrefactive change, and especially when it contains those living vegetable micro-organisms which now are recognized as associated with disease.

7. Much water is constantly being used which is contaminated by **sewerage** or other organic impurities. It does not always do appreciable harm, because our systems are so constructed as to adjust themselves to a certain degree of irregularity, and to resist slight or ordinary embarrassments. There is also another reason. Nature, chiefly through the action of the air mingled through or dissolved in the water, is constantly transforming that part of the organic or decayable matter which is carbonaceous into carbonic acid gas, and the harmful nitrogenous matter into insoluble nitre. Both of these, to the degree thus produced, are harmless. It is when this process is **interrupted,** or when the amount or kind of matter is such as not to admit of sufficient neutralization by these methods, that decomposable matters remain in the water, ready to act as fertilizers for forms of minute life so threatening to the higher life of man. The danger is, that in certain special conditions of atmosphere or temperature or locality, or of our own bodies, this organic matter will be roused into some peculiar or more rapid decomposition,

and that some form of disease-breeding animal or plant life will, from it, obtain that abnormal cultivation which will excite disease. This may take the general form of **irritation,** such as will produce **non-specific** disease, or it may prove **specific** in its character, and we then have cholera, typhoid fever, or some other deadly plague.

8. This brings us to notice the fact that, besides those defilements both of air and of water which are chemical in their nature, or have to do with foul gases, there is another source of danger which has come into great prominence in the last few years. It is found that both **air and water** abound with minute forms either of animal or vegetable life. To distinguish them from gaseous products, they are usually called "**particulate,**" as made up of particles. These are **intended** to be conservative of health and life, by feeding or nourishing upon those things not needed by man, and injurious to him. But when air and water are subjected to very abnormal conditions, and are continuously and extravagantly befouled, either these low forms of life multiply to an amount which nature cannot dispose of, or new and virulent forms spring up, which, getting into the system through air or water, give rise to specific forms of disease. This is known as the germ or **parasitic** theory of disease. These **microbia** or micro-organisms are oftener vegetable than animal, and are classified as are the lower forms of fungi in botany. The animal **microbia** are known as **microzoa,** and the vegetable as **microphytes.** Of the **microphytes,** we have various forms, as **bacteria, bacilli, micrococci,** and **spirochætæ.** These, implanting themselves on mucous membranes, and rapidly multiplying, are believed to cause fevers and various forms of communicable disease.

They have been traced both in foul air and foul water, but most frequently in water.

9. While it may be said comparatively that very much impure water is used which does not cause disease, it is always **hazardous.** As with filth-laden soil, so with fouled water. The system puts up with it, and, although with some increased expenditure of vital force, may overcome their ill effects or may adjust itself to them. **But too often the limit of endurance is reached.** Under some special conditions, or because of what seems to us the accidental presence of some specific form of animal or plant life, this decayable matter is just the soil to fertilize and render noxious the floating particle, and we become the host for that quick and wonderful life of organized matter which results in disease or death.

It is thus seen how **impure waters** do not always cause appreciable harm, and yet how at any time they may become the occasion of the most serious diseases. Very often, when no such results are recognized, the digestive system is disturbed, and the general vigor reduced. Many persons die from the diseases produced by impure water.

10. The water that comes from the sky as **rain-water** has mingled with it much air, and is the purest natural water. In its descent it gathers a small amount of mineral and organic matter, but this is likely to be much less than it finds in the ground. In cities, or where the smoke is dense, the water falling first is not so pure.

While we would not give to rain-water storage undue prominence, there must ever be much reliance upon it. There will always be places where rain-water from roofs, or prepared impermeable surfaces, constitutes the only source of supply for separate dwellings. We therefore

briefly outline the mode of its collection and preservation.

11. **Potable rain-water** is best collected on slate roofs. The leader should always be so arranged as that the first rain can wash off the roof and not discharge into the cistern. Two or three automatic arrangements are used for this purpose. This prevents any fouling from the dust of roofs, from leaves, or from the "cellulose or weather-beat" of shingle roofs. If a **leader** ends in a hogshead or tank proportioned in size to the roof, it can receive the first washing, and, when full nearly to the top, an overflow into the permanent cistern will carry off the pure, incoming stream, and leave the former to be used for non-drinking purposes. It is best, also, to have the mouth of the leader, as it leaves the roof, protected by a copper gauze, or a galvanized wire covering, so as to prevent any lodgment of leaves.

12. Whether **the cistern** shall be near the roof, in some upper room, or whether it shall be in the ground, will depend much upon convenience and locality. If near the roof, it should be well built, preferably in a circular form, or if square and lined, should have such lining as will not furnish *lead* or copper or too much iron to the water. The *overflow* should be so arranged as not, when its pipe is empty, to be an open tube to convey foul gases to the water. It therefore *should not enter* into the general soil-pipe. The cistern, while constructed so as to be accessible for cleansing, and while generally needing a covering, should not be so made as to confine stagnant air over the water.

13. When a cistern is placed in the ground, it should be deep enough to keep cool in summer and not to

freeze in winter, or to be cracked by the action of the frost. As the weight of water is ten pounds to the gallon, the receptacle for any large amount needs to be made strong. Cast-iron tanks, properly painted or dipped, after the Angus Smith method, are now often used. The **capacity** of the cistern should be ample, as it is best to store the water of long rains rather than that of occasional summer showers. The reason for this is that the first rain-water washes out the impurities in the air and upon roofs. If we reckon the average rainfall at thirty inches, or seventeen gallons a square foot, and allow a loss of six inches for the first water and short rains, and six inches for evaporation, there could be had from a roof of three hundred and sixty square feet, available for storage, five hundred and forty cubic feet of water, or three thousand three hundred and seventy-five gallons in the year, which, for the house, would be an average daily supply of nine gallons.

14. We next come to that supply of water which is derived from the **surface** of the ground. Although originally from above, it is variously deposited or retained in the earth. That which is found in lakes and streams is generally known as the surface water-supply. It is that for which nature has its own reservoirs, on the surface of the earth, in lakes and streams, which receive the drainage of water-sheds more or less extended. Sometimes, this is spoken of as of two kinds, namely, the surface-water from uncultivated or **sterile** lands, and that from **cultivated** lands, since the kind of soil through which the water flows furnishes it more or less with the organic matters which it contains, as well as with mineral ingredients. If the organic matter is so superabundant as not to be dimin-

ished by filtration through the soil, or oxidized by exposure to the air, it makes the water impure, while if limestone or other crumbling rocks abound, the character of the water is modified by these. Special **plants** may also give a peculiar odor to water, or, when in very great abundance, may add to it much decaying material. This water has the advantage that being on the surface it is exposed to air and sunlight, and by its motion over rock and pebbly bottoms is constantly aerated. How real is this advantage is sometimes illustrated by the **freezing** of rivers which are somewhat impure. Then, because of the exclusion of the air, the water, which in the summer was not complained of, in winter becomes scarcely fit for use. The disadvantage of such exposed sources of water is that they are subject to various artificial sources of pollution from cities, factories, dwellings, and soil enrichment.

15. The next **surface-supply** is that from **springs.** These are governed in position and depth by that of the different layers of the earth structure. Water, finding its way to an impervious bed, forms rivulets along that bed, and a water-level is there maintained. The direction of the slope, or dip of the slope, or a sudden change in the formation, causes the water to appear on the surface as a spring. If these are not deep they represent surface water of recent percolation through soil, and often rise and fall according to the abundance or lack of rain.

16. Next, is the water-supply derived from **shallow wells.** These wells are those which are fed by land or surface drainage. Though some of them are spoken of as deep, unless their depth is over twenty-five feet, "they depend

directly for their water upon the area immediately surrounding them, the rain-water falling upon which sinks downward and laterally toward the bottom of the well. The quantity procurable may be likened to the contents of a cone, the base of which is the area around the well, and its apex the bottom of the well, the contents being renewed from time to time as the rain falls. The extent of this area, or base of the inverted cone, is the greater the more porous the ground is for any given depth of well."

Such is the water on which, in the absence of public supply, most communities depend. By passage through the ground strata, and by this filtration and oxidation, it is usually pure, unless in its course it has derived contamination beyond the power of the natural forces in operation in the ground and air to neutralize. Not only are some soils, such as gravel and sand, more porous than others, but rocks also differ in porosity. Thus the new red sandstone is so porous as to act as a filter, and often removes much organic matter. Some kinds of rock contain organic matter.

Again we have the **deep well**, which represents what is sometimes called the resident water, or the more constant, deep water-level which is beyond the seasonal influence of drought or storm. To this class belong deep-dug wells, driven and bored wells, when deep, and artesian wells.

17. Of all these classes, it may be said, in general, that supplies nearest the surface may be very excellent, if only in the upper soil and surroundings there is no superabundance of organic matter. They even have the advantage of the more active and continuous presence of air for oxidation purposes. Their **risk** is, that pollution

of the adjacent lands or soils about them is more easily received by them than by the deeper reservoirs.

18. As to each of these we single out the more important suggestions and precautions. First, as to **river and lake** supply. Whether this shall be relied upon will depend upon the purity of the source, the character of the country through which it flows, the possibility of preserving it free from contamination such as would add to it decomposable organic matter, or such mineral matter as is harmful, or such taste either from mineral or vegetable sources as would give discomfort. If any such matters are added, the question also arises as to how far these are self-correcting in the flow and exposure of the stream, and what means can be used to prevent or neutralize the impurity. Also, as **a test** of actual condition, we need the repeated examinations of chemists, and the testimony of close medical observers, who, by actual statistics of sickness and death, and close observation and analysis of cases, will be able to give opinions which can serve as guides. Where, owing to appreciable and temporary causes, there may be contamination, or cloudiness, or discoloration, or taste, it is to be considered whether **filter-beds** or other methods may not avail for cleansing. Thus, even the taste and smell from water-plants, such as the nostochiæ species, are greatly improved by proper filtration.

19. The **character and conditions of the reservoirs** need to be carefully examined, both as to cleanliness and as to what is best for the agitation or aeration or protection from heat of the impounded water. For it is known that reservoir water is not always so pure as the source from which it comes. There are often no comparisons of con-

ditions and strange neglects of examination. We not infrequently find reservoirs that have not been cleansed for years, or properly investigated to know whether they are in need of cleansing, with gates or other wood-work or appendages in an improper condition, and with adjacent soil contamination by reason of added pollutions. Wherever a city is supplied with water by a company, it is especially important that knowledge as to these matters be sought. The **service-pipes,** too, are sometimes found in an improper condition, and those having intermittent supply may need aeration. The **growths** and **deposits** on these have sometimes been such as to affect water. If the joints are calked with organic material, as hemp, etc., the water is sometimes polluted and unpleasant to the taste. The plant-life of reservoirs and pipes sometimes needs microscopical examination.

20. Whether a river shall be used as the natural **drainage** for the adjacent territory, or whether it shall be practically the water-carriage for **sewage,** or whether it shall be the source of **water-supply,** is often a difficult and always a relative question. In a region where the rain-fall is large, and so many other sources of supply are available, rivers should not be resorted to where water can be obtained from series of wells, gravel-bed or other water-bearing strata, or impounded in reservoirs depending upon a supply high up amid uncultivated and comparatively uninhabited hills. This is accomplished by arresting the flow of the streams at a point high up in their course, where forests abound, or where there are few inhabitants. **Upland surface-water** from uncultivated grounds, which, after percolating through the soil, can be gathered either from springs or wells, or

from a kind of elongated well in the shape of a reservoir, on the edge of a hill, or so as to intercept a water-bearing strata, is by all acknowledged to be a most reliable source of supply, so far as the quality of water is concerned.

The average **rain-fall** of the country must, with due allowance, be taken into consideration, together with the amount of water likely to be needed. The general rain-fall is forty to forty-four inches. One inch of rain falling on a square foot gives rather more than half a gallon, so that forty-four inches of rain-fall a year represents a little over twenty-two gallons for each square foot.

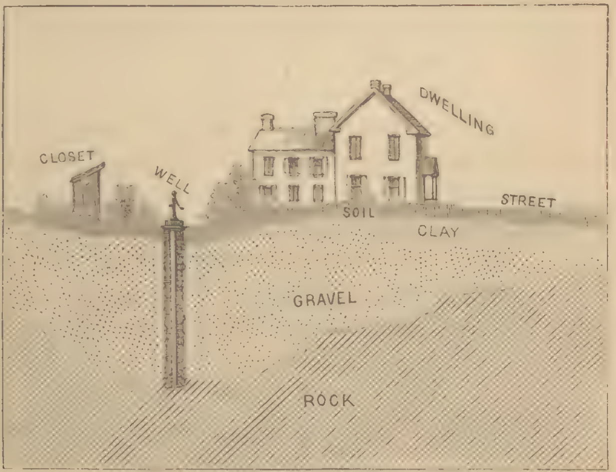
There needs to be a careful study of the natural **water-shed,** its underlying strata, its extent, what its loss is by rapid flow from the surface, by sun-heat and evaporation, and by any artificial interruption or addition thereto.

21. As to **springs,** although they generally represent water that has been filtered through higher ground and has reached a water-holding strata, it is to be remembered that springs thus open need careful protection from impurities, that they may be too highly charged with mineral ingredients, and that they may become affected by the pollution of the soil in their immediate vicinity.

22. **Shallow wells** are but elongated drainage-tubes laid perpendicularly instead of horizontally, and so, just as much as a field-drain, gather in the adjacent water. If the ground for a hundred feet or more around them has little organic matter in it, if it bears grass or other herbage to dispose of any organic matter in it, or if there is gravel or sand which forms a good filter for the descending rains, such water may be very good. But it is easy to see that wells that are not over ten or fifteen feet in

depth are liable to many possible contaminations. Therefore both the ground about them, and the sides and covering of the well, need to be protected from any sources of organic or decayable matter. Besides contamination from the soil above, or from carelessness about the covering or the apparatus used for drawing the water, the roots of **trees** near by, or the decay of the **wood-curb** that has been used in bricking or stoning up the well, may **cause impurity of the water.**

This diagram will serve to show how easily such wells may become contaminated from the surface.



Scale 30 feet to the inch.

FIG. II. — Showing different strata of soil and gravel.

23. **Deep wells** are generally safer, because they represent water-bearing strata out of the reach of surface contamination. They are openings into the pure reservoirs that are not much affected by what happens on

the surface of the ground. They give access to a purified residual water, which has a constancy of quantity and quality, and which, in long passage through the ground, has been thoroughly percolated. To this there are a few exceptions, by reason of the character of strata or local deposit. Such water also, by reason of the mineral character of the geological structure through which it has passed, or on which it rests, may have a mineral impregnation which gives it either valuable or disturbing mineral properties. Sometimes this deep water supply has such relation to hills or surrounding strata that it reaches the surface either through natural openings or through artificial tubes. These latter constitute the **true artesian** wells.

24. **Bored** or **tube wells** are merely the substitution of this form of access to the deep waters for the more usual form of dug wells. The tube well has the advantage over the ordinary deep well, in that the tube serves to shut out any organic matter from the surface which by reason of the artificial hole made from the surface might serve to let in organic matter from the upper soil. But even with these it sometimes happens that the upper ground does not pack closely about the pipe and that the **outside of the pipe** serves as a course or conduit by which foul surface or upper soil liquids may trickle down to the hidden well at the bottom of the pipe and be drawn up without much dilution.

25. **Tests of the Purity of Water.** — Too much dependence must not be placed upon opinions as to the purity of water derived from the preferences of persons accustomed to its use. Water may have no taste that would be criticised, and may seem very refreshing to the thirsty one, even when dangerously impure. Then, too,

by use we become accustomed to a particular water, and may prefer it regardless of its real purity. It seems to be a part of human boastfulness to claim that one's own well is the best in the neighborhood. Nor is it enough that no actual sickness has been traced thereto. It is marvellous how resistful some persons are to imperfect foods and drinks, and how the forces of a reserve energy of health either resist or compensate for depressing influences. Yet there are others who are more affected, and all are making a wastage of resisting power that is more wisely and usefully expended in some other direction. There is often need of such examination of waters as can be made only by sanitary experts. The chemist, the physicist, and those accustomed to study and weigh all the facts which determine the purity of water, may need to be consulted where the evil threatens serious results. The following ready tests, as suggested by Prof. R. C. Kedzie, will serve to guide as to the quality of water.

Color. Fill a large bottle made of colorless glass with the water; look through the water at some black object; the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or of solid matter in suspension.

Odor. Empty out some of the water, leaving the bottle half full; cork up the bottle, and place it for a few hours in a warm place; shake up the water, remove the cork, and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that otherwise does not appear.

Taste. Water fresh from the well is usually tasteless, even though it may contain a large amount of putrescible organic matter. Water for domestic use should be perfectly tasteless, and remain so even after it has been warmed, since warming often develops a taste in water which is tasteless when cold. If the water, at any time, has a repulsive or even disagreeable taste, it should be rejected.

26. **Heisch's test for sewage contamination.** The delicacy of the sense of smell and of taste varies greatly in different individuals; one person may fail to detect the foul condition of a given water, which would be very evident to a person of a finer organization. But if the cause of a bad smell or taste exists in the water, the injurious effects on health will remain the same, whether recognized or not. Moreover, some waters of very dangerous quality will fail to give any indication by smell or taste. For these reasons I attach especial importance to Heisch's test for sewage contamination, or the presence of putrescible organic matter. The test is so simple that any one can use it. **Fill** a clean pint bottle three-fourths full with the water to be tested, and dissolve in the water half a teaspoonful of the purest sugar, loaf or granulated sugar will answer; cork the bottle and place it in a warm place for two days. If in from twenty-four to forty-eight hours the water becomes cloudy or milky, it is unfit for domestic use. If it remains perfectly clear, it is probably safe to use."

27. The chief tests used by chemists in determining the quality of potable water are known as the Chlorine test, the Ammonia or Wanklyn test, the Frankland or Combustion test, and the Biological or Koch test.

In the Chlorine test, the amount of chlorides present in the water is determined, since chloride of sodium is a constant constituent of sewage, and the quantity in good water is very small.

The Ammonia test is based on the fact that most nitrogenous, organic matter may be made to give off a part or the whole of its nitrogen as ammonia, and on the view that the nitrogenous, organic matter is the chief source of danger. The ammonia thus obtained is called "albuminoid ammonia."

In the Frankland or combustion process a given quantity of water is evaporated, and the residue is submitted to an organic analysis which converts the carbon into carbonic acid and liberates the nitrogen. The relative proportions of carbon and nitrogen indicate the character of the organic matter.

The Biological method is the application of tests which determine the minute organisms in water, since impurity multiplies such animal and vegetable life therein as is believed to be often the efficient cause of disease.

As all of these require expert tests, they are only referred to here as showing how important to health such investigations are held to be, and how available they are.

28. It is clear, from all that has been said, that in sinking wells the greatest care needs to be exercised in their construction and as to the apparatus used for drawing the water. The stone or brick work, called the **steining**, must be of such material as has in it no organic matter, and the earth packed behind it must contain **no soil** or decayable matter of any kind. If a curb has to be used, it must be of wood that does not impart taste to the water, and does not readily decay. For at least five or six feet from the

surface the **steining** should be laid in cement, so as the better to keep out the upper surface-water.

29. The **apparatus** for drawing must itself be free of anything that would contaminate the water. If it agitates the water in the drawing, fresh air is thus mingled with the water, as many claim with advantage. Among more recent devices for purifying water, especially in reservoirs, has been the introduction of compressed oxygen or compressed air into the water, in order that any organic matter it may contain may be more readily oxidized and thus neutralized. Many wells are injured by not having a **covering** which will prevent the entrance of any liquid or solid substance from the top. The top of the well should be a little higher than the surrounding ground, and there should be no careless rinsing of vessels about it. The water supply is in daily use, and should be guarded as we would guard health and life.

30. Wells sometimes change in the **quality** of water. This may be owing to something having fallen into the well, to a seam in the adjacent or underlying rock which has become saturated with filth from some distance or serves as an inlet for some cesspool, or to some sudden discharge or pressure from a cemented vault or some other source. More frequently it happens that a cesspool or slop-pipe, or other foul source of organic matter, has for a long time allowed the soil not far off to become saturated. **Boil, cool, and aerate suspicious drinking-water.**

31. **Lead pipe,** because of its convenience and pliability, is often used to bring water from wells or springs into houses. All waters contain more or less dissolved oxygen. This, combining with particles of the lead, may get into the system and cause that peculiar affection known as

lead-poisoning, and so often taken at first to be rheumatic pain. Saline substances, sometimes present in waters, seem to increase this action of the oxygen on the lead. This is especially true of the ammoniacal salts, the nitrates and the nitrites. In some cases, the pipes become coated, so as to be protected from action where the water itself would otherwise produce it. So many and various have been the cases of digestive irritation, of wrist-drop, and of other affections of the system from lead-poisoning, that if lead be used, it is always recommended to run off from the pipes all water that has stood all day or all night in them, and not to use for drinking or cooking any water which has passed through the pipes when hot. **New pipes** are especially hazardous, and should be emptied frequently. Pipes from a public water supply are not as hazardous as those from wells or springs. Where a **lead-pipe** runs down to a **well,** and water is drawn through it by suction, the union of oxygen with the lead is often rapid, and instances of lead-poisoning from these are most frequent. Why some persons are so much more susceptible to lead-poisoning than others has not been explained.

32. **Filters and Filtration of Water.**—Water that is cloudy in appearance or unpleasant in taste is sometimes much improved by the use of a filter. This acts as a strainer to remove minute particles. By using materials which are not compact, but have spaces between the particles for air, the water is brought into contact with it, and some oxidation of organic matter takes place. It is also claimed that in the use of some substances there is chemical change, so that organic matter is neutralized and rendered harmless. While there is no evidence that specific

particles, such, for instance, as give rise to typhoid fever, would be removed, the clarification and purifying of the water removes materials from which lower forms of life derive their pabulum. One objection to filters is, that if the impurities left behind in the filtering material are not occasionally washed out or removed, they remain to be decomposed. Yet filters act chemically as well as mechanically, for they bring the oxygen and nitrogen of the air into closer contact with the divided particles of water, so that in place of the organic carbonaceous matter we get dissolved carbonic acid, and in place of the nitrogenous matter, a small quantity of harmless nitre.

The **great filter,** as we have seen, is the earth through which the surface and rain water is passed to lower beds or strata, there to form the water-level in the ground, down to which we sink wells, or from which springs appear at hillsides or other points where there is change of strata. The perfection of this filtration depends much upon the character of the ground. If there are alternate layers of gravel and sand, or gravel only, the percolation or filtration is generally quite perfect. But if there is much organic matter in the soil, or mineral matter that can be dissolved, the water instead of being filtered is charged with it.

33. Filtering is done on a large scale when large filtering-beds of sand, gravel, etc. are made in connection with reservoirs, so that the water can be filtered before it is distributed to houses. As generally constructed, they are water-tight basins with the sides built in masonry. The bottom is cemented, and piping or channel-ways are made upon it, so that the water after passing through the filter-beds may find easy access out. On the bottom layers

broken stone is placed, and above it screened gravel of uniform size, and on this, one or two layers more of smaller size, the thickness of each being about three inches. Over all are two or three layers of sand arranged in similar manner. The water is let on from the reservoir so as to cover this filtering-bed a few inches in depth, and is allowed to flow through it at a regulated rapidity. Occasionally, the water is drawn off, so as to expose it to the air, and to cleanse it or replace the upper layers of sand.

To obtain the best results, the filtering material should be frequently aerated. **Air** is a far better cleanser of a filter-bed than water.

The idea, then, of a perfect filter is one which, by the mechanical arrangement of the parts of which it is composed, secures the most perfect mechanical separation of every particle in suspension in the water; which, by adhesion to its surfaces or "mechanical entanglement" in its pores arrests these particles, and which also, by this arrangement, secures the most perfect facilities for the aeration of the water and oxidation of all organic matter in it.

34. Cisterns are often well provided with filters of their own, by having a **partition** of brick, so that the water passes into one side and out through the other. A solid brick wall, laid carefully in cement mortar, makes a good filter. The bricks should be rather underburned, extending through from one side of the wall to the other, and the faces of the wall not covered with mortar. Water will filter through such a wall fast enough for the supply of a family, and if the rain all enters the cistern upon one side of the wall and is drawn out from the

other side, the water is clean and sufficiently pure. Such cisterns should be occasionally cleaned out, and the partition wall scrubbed. If, by an ordinary bellows, air is blown through the brick septum from the side opposite to that on which the roof water comes in, it helps to restore its straining power.

35. There are various forms of **house-filters**, some of which are cheap and valuable. Flannel tied on the faucet of the water-pipe will greatly improve the appearance of drinking-water, and will strain out much organic matter. A tube or box with sponge in it will also be satisfactory in clarifying turbid water, and it is easily and quickly washed and replaced. A sheet of filtering-paper, as used by druggists, in a glass or tin funnel, furnishes a good means of filtering water on a small scale. A fresh sheet of filtering-paper will be generally needed each day. Granulated, animal charcoal, in boxes or vessels where the water can filter slowly through it, improves its appearance and quality. A common form of filter may be described as follows:—

36. Take any common vessel perforated below, such as a flower-pot, and put a small, clean piece of sponge over the hole. Fill the lower portion with gravel-stones, over which place a layer of finer gravel, and on these a layer of clean, coarse sand, the proportion of each being about the same. On the top of this place a lid of unglazed clay, either very porous, or perforated with small holes, and on this a stratum, three or four inches thick, of well-burnt animal charcoal. A filter thus formed will last for a long time, is easily cleaned, and will be found to act both by mechanical and chemical purification.

The following are good directions from so good an authority as Dr. Parkes:—

"Get a common earthenware garden flower-pot; cover the hole with a bit of zinc gauze or a bit of clean-washed flannel, which should be changed from time to time; then get some rather small gravel, wash it very well, and put it into the pot to the height of three inches; then get some white sand and wash it very clean, and put that on the gravel to the height of three inches; then take two pounds of animal charcoal, wash that also by putting it into an earthen vessel and pouring boiling water on it; then, when the charcoal has subsided, pour off the water, and put some more on for three or four times. When the charcoal has been well washed, put it on the sand and press it well down. Have four inches of charcoal, if possible. The filter is now ready. Pour water into the pot, and let it run through the hole into a large glass bottle.

"After a time the charcoal will get clogged; take off a little from the top and boil it two or three times, and then spread it out and let it dry before the fire. It will then be as good as ever. From time to time all the charcoal and the sand also may want washing. The sand may be put over the charcoal, and not between it and the gravel; but this plan sometimes leads to the charcoal being carried, with the water, through the gravel and out of the hole. The sand stops it.

"By filtering in this way, and by boiling the water, many dangers are done away with."

Another similar suggestion is as follows: Use a simple glazed earthenware jar, holding five gallons, or even less, having a double bottom. The upper bottom has a small hole, closed by a bit of sponge; the space of

four inches or so between the two bottoms is packed with clean gravel, above which is fine, clean sand; the lower bottom is perforated with very fine holes, through which the water slowly passes to an earthenware vessel below, into the top of which the filtering vessel tightly fits. The water is drawn off from the lower vessel by a faucet. If this lower vessel is unglazed, it will serve at once as a cooler and reservoir.

Charcoal has been objected to, because, if not occasionally changed or if impure, it attracts minute forms of animal life. This is not true of the fresh animal charcoal, which removes not only a large proportion of the organic matter in water, but also a not inconsiderable amount of mineral saline matters.

37. The other chief filtering materials besides those named above are spongy iron, the magnetic carbide of iron, and silicated carbon.

Spongy iron is prepared from the common hematite ore by fusion, and yields iron in a porous and granular condition. It is said by the Rivers Pollution Commission of England to be a very active agent, not only in removing organic matter from water, but also in materially reducing its hardness and otherwise altering its character.

The magnetic carbide of iron, which is similarly used, is obtained by heating hematite with saw-dust.

Silicated carbon consists of charcoal, silicon, and a little oxide of iron and alumina, and is highly recommended for filtration by Wanklyn.

While too much reliance must not be placed on filters, yet they are often available means for correcting the taste and improving the general quality of the water. Even

without the direct chemical effect claimed by some, they act as minute **strainers,** and by bringing air in contact with the water, oxidize that organic matter by which the lower forms of animal and vegetable life are sustained. Of the putrescible material, they at least remove much of the matter upon which the lower forms of animal and vegetable life are nourished, and so are of service.

These filters require cleansing or the occasional renewal of the filtering material. They should not be closed so as to keep water stagnant upon them, but may now and then be allowed to run dry, so as to refresh with air the spaces between particles. Where there is the least suspicion of well-water, **boiling** and **aerating** it **by pouring** from one pitcher to another is a good precaution. It is often well to consult the family physician, who may aid in the more simple tests; but if there is good reason for suspicion, he will advise you not wholly to rely upon these approximate results, but direct you to those who have more experience in the work, and the advantages of laboratories with all appliances needed.

38. **Hardness of Water.**—**Lime salts** are the chief cause of hardness in water; compounds of magnesia, iron, and other elements, however, may contribute to that soap-destroying power of the water, which is practically meant by the term. Chemists recognize two kinds of hardness: (1) **Temporary hardness,** which is caused by the presence in the water of elements held in solution from which the carbonic acid can be separated by boiling. Thus the carbonic acid holding them in solution is driven out, and the precipitate this held then separates in the solid form, and can be removed by filtration. (2) **Permanent hardness,** which is caused by the above bases, which are

in combinations **not converted** into the insoluble form by boiling,—sulphates, chlorides, etc., chiefly the first named. The temporary and permanent hardness together constitute the "total hardness." In general it is correct to say that hardness produced by earthy **carbonates** is "temporary hardness," because it can be removed by boiling, while that produced by the earthy **sulphates** is permanent hardness because boiling does not remove it. The first is chiefly in the form of chalk and the latter of gypsum,—the former being a carbonate of calcium or carbonate of lime, and the latter a sulphate of lime. It is the former which is especially noticeable in some waters, which diminishes their value for culinary and manufacturing purposes, and which in some persons causes indigestion or inorganic deposits. In Glasgow it is estimated that the consumption of **soap** has been diminished one-half since the introduction of soft water. Every grain of chalk or calcium carbonate wastes eight or nine grains of soap. Not only does soft water need less soap, but it is much better for making tea and soups, or for boiling meats or vegetables. Those who have to use hard water for making tea often add a little soda in the pot so as to precipitate the lime. Boiling does this somewhat, as is seen by the hard incrustation in kettles in which much hard water has been boiled. This not only makes more fuel necessary, but, as in the case of steam-boilers, weakens and injures the metal. As a unit standard, **water is said to be hard** when there is one grain of bicarbonate or sulphate of lime to a gallon of water. Ten grains of hardness is generally spoken of as the limit for culinary and drinking use, and even so much is not desirable.

39. The hardness of water may be greatly diminished by what is known as the Clark process. The explanation of the process is as follows: Chalk, or carbonate of lime, becomes bicarbonate of lime when it is dissolved in water by carbonic acid. **On adding lime, it unites chemically with the carbonic acid,** which ordinary water contains, and forms chalk. The chalk formed, or the chalk originally present, having now no carbonic acid to hold it in solution, is thrown out of solution and is slowly deposited. This removes the hardness which was caused by the bicarbonate of lime. **Milk of lime** is the form in which the addition is generally made. Ordinary lime-water, kept in a stoppered bottle and added to hard water, will soften it. In the Porter, Clark, and Atkins processes the separated chalk or lime is at once filtered out through cloths.

40. **Aerated water** is made by shaking good ordinary water with carbonic acid gas, in proper vessels, under pressure. The general name for it is **soda-water,** because the original effervescent fluid contained soda. True soda-water contains fifteen grains of bicarbonate of sodium to the half-pint, but the "soda-water" which is sold for drinking has simply been aerated with carbonic acid. It quenches thirst and slightly exhilarates. Ginger-beer and various other forms of drink are but aerated water, with some flavoring condiment.

41. With the increasing evidence that water is often a conveyer of disease, and that frequently, by its impurities, it depresses the vitality of the system, it becomes **the duty** of every person to be familiar with the ordinary impurities, and with some of the methods of their detection. So long as by the boiling of water, by aerating it, and by various other methods, we can protect ourselves from these risks of impurity, we should not fail to do so.

42. There is need of some caution as to the use of **ice** and **ice-water.** By chilling the stomach, we may cause a sudden arrest of digestion. Ice is not so purified in the act of freezing but that it will partake of the character of the water from which it is formed. Minute worms have been taken alive from pond-ice some months after it has been frozen. Minute forms of fungoid or cryptogamic life are not destroyed by freezing. Outbreaks of disease have been traced to the use of impure ice.

CHAPTER IV.

AIR, LIGHT, SUN-HEAT, AND CLIMATE, AS RELATED TO HEALTH.

IF earth and water are indispensable to human life, not less so is that gaseous mixture called **air** which pervades our globe, and which, when received into the lungs, accomplishes changes in the blood on which life directly depends. From 1,500 to 2,000 gallons of inspired **air** are each day received into the human system. A single inspiration of an adult takes into the lungs about **thirty cubic inches.**

2. Pure or normal air consists of a mixture of the gases known as **oxygen** and **nitrogen.** The mixture is a mechanical and not a chemical one, but the properties of the two gases vary somewhat. The oxygen is more soluble in water, and hence, as we have seen, is found in a larger proportion in water than in the open air. The oxygen and nitrogen of the air have the proportion, by volume, of 20.61 of oxygen to 77.95 of nitrogen, or, by weight, of 23 parts of oxygen to 77 of nitrogen. The general statement is that air is composed of one part of oxygen and four of nitrogen. Oxygen is the most active constituent, as through its agency the most important changes are wrought. Sometimes nitrogen is spoken of as a mere diluting agent, but it has other incidental uses.

3. **Carbonic acid gas,** or carbon dioxide (CO_2), is always present in the air in from three to four parts in 10,000,

but its presence is not known to be related to animal life. To this extent it is generally claimed as a natural constituent of air. But if increased to six or seven parts in 10,000 it becomes a direct interference with health, and when up to ten parts is very injurious to most persons. If increased to more than this, it will destroy life. It is heavier than oxygen or nitrogen, and so, unless heated, tends to sink into the lower strata of air. Its production is going on constantly in all combustion processes and the respiratory acts of all animal life. It is one of the gases of decomposition. **Vegetation** appropriates much of this product.

It has sometimes been claimed that plants and flowers are healthful in living and sleeping rooms because of this. It is true that **green** and **living** plants in air or sunlight do appropriate carbonic acid gas. But dead leaves and flowers do not. With all the moistening and enriching necessary to house-plants, they certainly do not improve house air, and deteriorate it **unless** they are green and well attended to. **Ammonia** is also present in small quantities in the outside air. **Ozone,** which is oxygen in a condensed form, is present in certain qualities of air, as that in the open country or amid mountains and forests. It seems to have a greater power of oxidation and purification than oxygen itself, and is claimed as a test of the value of some localities as health resorts.

4. The air always contains more or less **aqueous vapor,** which is insensible to ordinary vision and feeling, or appears in fog, dew, rain, snow, or hail. Air is said to be **saturated** when it will hold no more moisture. But by raising the temperature the **capacity** for moisture is increased. The amount generally present varies from fifty

to seventy-five per cent. Where the air is both high in temperature and saturated with moisture, the heat becomes especially oppressive. The wind of very hot and saturated air is not cooling.

5. Air has impurities added to it in various ways. If taken into our lungs, it comes out with a loss of about five per cent of oxygen and a gain of about five per cent of carbonic acid. The expiration of carbonic acid is greatest during the day. With this are associated impurities of an **organic** nature, such as putrescible particles of various kinds and some of the gases of decay. An adult will, with usual activity of life, exhale about twenty cubic feet of carbonic acid gas, and thirty grains of unstable organic matter, in each day. This amount is much increased by great activity or by a bad condition of health. This does not include organic material from the skin or other sources which also get into the air. Numerous impurities get into the air **from without.** All combustion, from the burning of a candle to that in the engine, consumes oxygen and gives out carbonic acid gas. Smoke, gas, dust, all forms of organic particles, minute specks of all vegetable and animal life, find their way into this great ocean of atmosphere above and around us. One has only to let the sunshine strike through a small chink in an apartment to see what multitudes of floating particles become visible. These are but specimens of a countless host too small to be seen by the unaided eye. In addition, there are minute forms of vegetable and animal life in countless numbers, some of them conservative of purity, but many of them, by their excretion or changes, adding to the suspended matter of the air.

6. In the out-of-door atmosphere, the provisions of

nature are in general fully adequate to the care of all the exhalations of the earth, and all the forms of mineral, animal, or vegetable matter, without risk to human life or health. There is such diffusion and chemical combination as not only to neutralize but to change these into valuable material. But in the **artificial conditions** of life, where there is not the same opportunity to carry far away the floating material or to neutralize it, or where the product is far more rapid and abundant than in natural conditions, we get such production of impure air as is dangerous to human health, and must be provided for by various methods of adjustment. In many industries and arts there is great liberation of deleterious matters.

7. **All impure air** has a tendency to irritate the minute membranes of the throat and lungs, and to deprive us of that amount of oxygen needed for healthy respiration. The breathing of foul air, also, enfeebles lung power, diminishes skin circulation, and makes us much more liable to colds and other maladies. The minute forms of organic life, intended for conservative uses, are so over-nourished by such abundant material as to take on exuberant growth and multiplication. So the higher life is too often embarrassed or succumbs to the conditions of foulness, which make these lower forms disease-breeding and pestiferous.

8. It is not wonderful that so many diseases result from foul air when we consider how dwellings, assembly-rooms, and all indoor industries, tend to accumulate deleterious substances, to prevent free circulation of air, and to produce the gases of decay. Modern life has greatly added to these evils. Houses are built more compactly. Heat is introduced from cellar to attic. The gases from fires

and lights add to the carbonic and other gases unfriendly to health and life. A usual **gas-burner** removes as much oxygen and produces as much carbonic acid gas as four or five men. It is only not so harmful because not laden with organic and decayable matter, but is still deleterious, and in large quantities destructive of life. Various other worse forms of gaseous substances are produced, as carbonic oxide, marsh-gas, sulphuretted hydrogen, etc. Even where the air is only confined and dry, we have a great sense of relief in the change to the purer air of the open country.

9. **Purity of Air.** — There are various ways by which we test the purity of air. The most ready and common of these is by **sense of smell,** so that when we pass into a room differing a little in purity from the outer air we perceive a difference. But the trouble with this test is that this sense is so easily blunted, and what we once perceived soon becomes unnoticeable. Besides this, there are other impressions made upon the sensory system, as when we are conscious of **dryness,** or of feeling uncomfortable in a close room, or in certain conditions of atmosphere.

10. The chief reliance now is on microscopical and chemical examination of the air. With the microscope, we are able to detect the various floating particles, and to determine whether they are organic, and if so, whether alive or dead, and if inorganic, what form of substance they represent. The thermometer, the barometer, or the hygrometer come to our aid in determining questions of **temperature** and **moisture.**

Chemical examination has aided very much, and especially as conducted by R. Angus Smith in his studies

of chemical climatology. He devoted himself much to the examination of outside air, and shows how, notwithstanding the laws of diffusion, the air of towns, with its smoke, its particles and acids and gases, is not so uniformly good as that of the country, and that the air of mountains and valleys differs from that of closely-built country districts. Suffice it here to say, as to chemical examination, that it is now possible to estimate the **carbonic acid** and various other gases, and the **organic impurities** contained in the atmosphere, as well as many of their sources and the amount produced. It is upon these that many of the rules as to heating and ventilation are based, as will be seen in the chapter on that subject.

11. Our standard of pure air is to be derived from its composition as found in nature, and from the experiences of careful observers as to localities where the air is found especially beneficial. Thus it is a valuable fact, if it can be shown, that ozone or condensed oxygen abounds more in hilly than in city districts, and that such air is to be considered pure and more beneficial for this cause. Having ascertained fully what constitutes pure air and the deterioration to which it is subject, we are ready to consider what are the qualities needing to be supplied to persons living or kept in inclosures, under certain defined conditions as to position, numbers, etc.

12. The quantity of air needed to be supplied to a room containing a given number of persons has been variously computed. In order to approach correctness, many facts have to be taken into consideration. Thus a room occupied as a hospital produces air of a greater degree of foulness than the usual room as occupied by well

persons. Something depends on the mode of building, since some houses have more windows, cracks, and crevices than others, or have walls of less thickness, or are so inclosed as to cause dampness, and interfere with the free and rapid distribution of air. The design of houses should not be to **exclude air,** but to **introduce** it without undue draught. Even the walls should not be air-tight. Rooms differ much as to the amount of dust, or other forms of animal, mineral, or vegetable matter introduced into them, as well as in its readiness to decomposition and decay. As fires and lights consume oxygen and furnish carbonic acid gas, and as these are often associated with dust and various gases, and with varying currents or movements of the air, these too are to be considered. Sanitarians have not failed to take into consideration all these modifications; to experiment upon the effect of different causes, or of several of them differently combined. The first basis generally considered is that of the needs of each individual.

13. Not far from 400 cubic feet of air passes through the lungs of each person in a state of ordinary activity every twenty-four hours. In this time, the lungs take out of the air about 18 cubic feet of oxygen, and put into it about 18 cubic feet of carbonic acid gas. In the same time an average of about one-half pint of impure water goes out from the lungs, and about 30 grains of putrescible organic matter, in addition to as much or more from the skin. Children are more active in their vital processes than older persons, and in the period of school-life are generally reckoned as needing about the same amount of air as adults.

14. If we rest our calculation on the amount of carbonic

acid gas exhaled, which is quite an approximate measure of **other impurities**, and upon the amount of oxygen removed, there would be about 17 cubic feet of air that has been disposed of each hour, and so disposed of as not only to deprive it of its purity, but to give back into the remaining air materials which, with every one of the eighteen expirations per minute, was reducing its purity. If a person should be shut up in an air-tight box, ten feet long, ten feet wide, and ten feet high, it would be but a very few minutes before there would be a cry for more air. As an ordinary stove, burning anthracite coal, for every pound of fuel burned consumes $2\frac{2}{3}$ pounds of oxygen, or 32 cubic feet, corresponding to the amount in 1000 cubic feet of air, this greatly adds to the exhaustion. As the combustion of one cubic foot of coal or lighting-gas consumes the oxygen of 10 cubic feet of air, and produces 2 cubic feet of carbonic acid, the demand would be all the sooner if lights were being used. One pound of oil consumes the oxygen of 130 cubic feet of air, and produces about 21 cubic feet of carbonic acid. Whenever the heating is done by apparatus located in the room, a consumption of oxygen takes place, with the addition of dust and gases. This is only partly compensated for by the **draught** caused.

A careful study of these facts, and careful tests of the quantity of these constituents in the air of various rooms, has led to the following conclusions, which, although not claimed as absolutely accurate, are so approximate as to have received the assent of the best authorities.

The minimum amount of cubic space in a room which should be allowed for each person is as follows: —

In a school-room	250	feet.
In a dwelling, in a room constantly occupied all day or all night	300	"
In a tenement or lodging-house	350	"
In a hospital ward	1000	"

In computing cubic space two things are by experiment shown to be essential. First, that the **height** of a room over twelve feet should be disregarded; and, second, that of the cubic space, the **floor space** should not be too little. Three by four, or twelve square feet, is the smallest floor space approved of for each pupil in a school-room.

The bases of these calculations are, first, the amount of cubic feet of air per head needed each hour; second, the necessity of so introducing it as not to cause draught; and, third, the general result of experience as to the effects produced by lesser quantities.

15. To supply the amount of pure incoming air necessary to change the air **without draught,** so as to keep the carbonic acid, etc. below the standard of from 6 to 7 parts in 10,000, it is found that at least three times the amount of air per hour needs to be introduced that is allowed for the cubic space. Where there are fires and lights which derive their combustion by consuming the oxygen of the room-air, the amount often needs to be doubled. With this general statement as a guide, it needs to be said, in addition, that so many are the modifications arising from exposure of location, from material and shape of inclosure, from prevailing winds, from changes in atmosphere, from character of audience and length of occupancy, that it often seems desirable to make local tests by the thermometer, the hygrometer, the Angus Smith carbonic acid test,

the senses of persons coming in out of pure air, besides a few chemical tests which may be resorted to.

16. The Angus Smith test is thus stated: **Keep the room** so that the air gives no precipitate when a ten and a half ounce bottle is shaken with half an ounce of clear lime-water. To make the test, clean a wide-mouthed bottle and fill it with pure rain-water. Empty out the water in the room so that the bottle will fill with the room-air. Wait until it is dry and pour into the bottle a half-ounce of clear lime-water and shake thoroughly. If there be no trace of turbidity or milkiness, it does not contain more than eight parts in 10,000 of carbonic acid gas. This will show that the amount of carbonic acid present is not beyond the amount consistent with health.

Ammonia, sulphuretted hydrogen, and ammonia sulphide when present can be detected as follows: For the ammonia test tincture of logwood is evaporated to dryness and the residue dissolved in ether. Strips of filtering-paper are dipped in it, to which ammonia gives a brownish color. In the Frankland water-test process we have already noted the significance of ammonia. Sulphuretted hydrogen is best detected by exposing strips of blotting-paper dipped in a solution of acetate of lead.

Ammonia sulphide is detected by paper dipped in a solution of nitro-prusside of sodium. All these are associate gases of decomposition.

17. **Moisture of Air.**—Although we have already spoken of water, we need again specially to notice it as a constituent of air. For the relation of health or life to the moisture in the air is not less vital than to the air itself. About twenty-two per cent of all the heat that

leaves the body passes off by evaporation. Upon it our comfort largely depends. This evaporation depends much upon the amount of **moisture** in the air. Leaving out of consideration that which is condensed and appears as rain, frost, hail, snow, or dew, the insensible moisture of the air, like the insensible perspiration of the body, is one of the essential, regulative forces for health.

There is a sense in which the atmosphere in which we live may be said to consist of a mechanical mixture of air and watery vapor.

Air is said to be saturated with vapor or moisture, when the space occupied by the air and the vapor will not admit of the presence of any more vapor. But the *capacity* of air to contain vapor of water increases rapidly with the increase of temperature.

Prof. C. F. Brackett illustrates it thus: "If one pound of air at 32° F. were saturated with moisture it would contain .00379 pounds of water. If, now, the whole were heated to 42° F. it would no longer be saturated, since at this temperature a pound of air would be capable of holding .00561 pounds. Merely heating the pound of air together with the vapor contained in it has changed its hygrometric state from complete saturation to one which is only 68 per cent saturated. In like manner, if the temperature were successively raised to 52°, 62°, 72° F. the corresponding degrees of saturation would be 46, 32, and 23 per cent."

18. As **evaporation** from our bodies is to us not only a comfort but a condition of health, if we are placed in an atmosphere **warm** and **saturated** with moisture, we are far more uncomfortable than in an atmosphere of greater warmth with less moisture. If, however, with a raised

temperature, the degree of saturation with moisture falls very low, as to .23, we ourselves are called upon to impart more, and great dryness and discomfort result. While we have not control over the outer conditions of moisture, we can, by change of clothing, of exposure, and of climate often get the desirable or necessary results.

It is a **fallacy** to suppose that the windows of a room must be closed on wet days to keep the damp out. **Damp air** is only hazardous when the point of saturation is nearly reached. With the temperature of a room moderately high and the introduction of air without direct draught, the damp outside air is far better than the confined air within. When we come to speak of ventilation and heating we shall have occasion to consider more fully the artificial relations of in-door life to air, and how they can be regulated.

19. **Light as related to Health.** — In considering the eye we shall have occasion to consider light in its special relations to it. But besides this, light has a very important influence upon general health, growth, and increase of vigor. It is one of the **conditions** of vital action. Carter the oculist speaks of it thus: "The potatoes which germinate in a dark cellar and push out straggling white and sickly roots toward any chink by which sunbeams penetrate the darkness, the artificially bleached celery and sea-kale of the gardener, the children who grow up in shaded lanes and dark alleys of great cities, the work-people who labor in cellars or mines, all alike proclaim the great truth, that light without sunlight is only half living."

Want of sunlight, to the human race, means stunted bodies, imperfectly formed blood, feeble limbs, dull senses, and torpid minds. Essential to the well-being of those

who are reputed to be healthy, it is no less essential to the recovery of the sick. There are well-authenticated instances of hospitals having a light and a dark side in which the percentage of recovery has been distinctly greater on the former; and a like influence upon the health of inmates has been repeatedly observed in schools, barracks, asylums, and other public buildings. "Who," says Miss Nightingale, "has not observed the purifying effect of light, and especially of direct sunlight, upon the air of a room?" It is well known that the inhabitants of those sides of deep valleys on which no sunshine ever comes are apt to be pale, stunted, and deformed.

20. The value of **sun-baths** was known to the ancients. While there must be some adjustment to circumstances, it is certain that it is desirable to have not only light, but sunlight, enter living-rooms and school-rooms. Also, that there be enough windows to secure light nearly as it is had in the great open. Because sunlight tends to bleach curtains and other adornments, it is too often shut out where most needed. It is far better to choose fabrics that will not be thus affected and that have no folds for retaining dust. A thin material will subdue direct solar light, so that it will not dazzle and yet admit the warming rays into the room. Fluted or ground glass will change the rays of the sun, and yet increase the amount of light that finds entrance, and can be used in certain windows of schools with advantage.

21. The effort as to every school-room should be to have no interruptions to full light. Many city **school-rooms** by reason of adjacent buildings, and many country school-houses by reason of adjacent trees, are too much shaded. Ever bear in mind that it is not merely a question whether

one can see, but also whether the cheering and healthful and transforming power of bright, pure light is secured. No doubt the direct rays of the sun will sometimes show an amount of particles floating in the atmosphere of the room sufficient to surprise those who regarded the air as very pure; but this will only serve to emphasize the need of avoiding all kinds of dust in the school-room.

The effect of full light, if let in from proper directions, is always to aid in comfort as well as in health. When not occupied, buildings and rooms are greatly benefited by the free admission of sun as well as air, so that all **dampness** may be overcome, and **sun** and **draught** may unite in their cleansing and purifying work. Many experiments have been made which show the effect of different degrees of light. Good authorities claim that, were it possible, school and other houses should be located with their **corners** toward the **cardinal** points, as thus we are more likely to secure some sunshine in each room on every sunny day.

22. **Electricity,** as contained in the atmosphere, and as related both to light and heat, is also to be regarded as associated with the air and as modifying its conditions. But neither science nor experience as yet enable us to speak of it in this relation, or of its general influence on health.

23. **Heat as related to Human Health.**—While heat has so many and such important relations to human health and welfare, its chief consideration needs to be deferred to those chapters in which we consider our clothing and our foods, and the action of the body as related to heat.

As a general statement, the **sun** is the source of all heat.

Materials are divisible into those which are good or bad conductors of heat. As heat becomes stored in various substances which thus become known as fuel, so animal heat is stored in food. One of the chief activities and functions of the human body is to **convert** other substances into animal heat. Being thus converted, it is often a question how to so relate the body to clothing and to the outer world as to **hasten** the removal of heat when desirable, and to secure **retention** of heat when we need more warmth. By the laws of conversion and adjustment, the body tends to such an equality of internal heat that 98.6° F. can be stated as the normal temperature. But notwithstanding this, our sensations are subject to varied impressions of heat and cold, such as affect the health even when not changing the internal temperature. Or if the shock is great, or a disease intense, the internal temperature may be raised from the normal standard to 105° or more, but with great risk to life. The production of heat for us by means of foods, and in most climates by the artificial aid of fuel, is an indispensable necessity.

24. Our best warmth is that derived from foods and from exercise and other natural stimuli of internal processes. Next to this, is the use of such variations in day and night clothing as will retain sufficient heat to prevent chilliness and make us comfortable. The consideration of all this will find its place in connection with the subject of Heating and Ventilation.

25. Climate and Health. — Most of these surroundings, or outside influences, that we have been considering, go to make what we call the climate. **Meteorology** is the science which treats of the atmosphere and its phenomena. **Climatology** is the science which treats of the

causes which affect **the climate at a particular place.** By the *climate* of a place, we understand its peculiar condition with respect to temperature, moisture, and other atmospheric phenomena. By *weather* we understand the condition of the atmosphere at a particular time with respect to temperature, moisture, winds, cloudiness, etc.

Climate, while depending primarily on (*a*) the distance from the equator, (*b*) the distance from the sea or very large bodies of water, (*c*) the height above the sea, and (*d*) prevailing winds, *depends also* (*e*) on the drainage of the ground, (*f*) the character and contour of the geological structure, (*g*) the amount of forests, (*h*) the rainfall, (*i*) the cultivation of the soil, (*j*) the access of light and heat, and other minor influences.

26. Hence, in studying climate, we are studying the effect of various combinations and modifications of our surroundings. Continental and oceanic outlines; the interspersion of islands in the seas, and of lakes in the lands; the disposing of mountain-chains and forests, to interrupt or change the direction of winds and to condense the moisture they bear; the courses of the valleys, determining those of the rivers; the character of the soil in respect to radiation and absorption of heat; the nature and extent of vegetation; the slope, as to sun and wind exposure; and various other things, affect climate in general, and even give a variety of climate to localities not far distant from each other.

While instruments of precision and the classified observations of many observers furnish us general indications, we often have occasion to take these only as guides, and then learn by our own experience what locality is best fitted to our own physical condition. Health often depends

either upon change of locality, or upon a proper adjustment of ourselves to the conditions of the locality in which we have to reside.

Our houses and our clothing are among our first and most important attempts at this adjustment, and have value to the extent that they serve to adapt us to our surroundings. As these are the primary artificial efforts we make to adjust ourselves to our surroundings, and as the *skin* is the medium of contact with the world about us, these will be considered when we come to treat of it.

Chapter V.

SHORT LESSONS IN THE ANATOMY OF THE HUMAN FRAME, AS RELATED TO THE HYGIENIC CARE OF THE BODY.

HAVING thus considered the more immediate surroundings of man which have most to do with his life and his health, before any further consideration of these or of other natural relationship with the outer world, it will be necessary to pass to another division of Hygiene, namely, to such consideration of human structure and function as will enable us to present those mutual relations and conditions which have to do with the maintenance of health. In so doing, it will also be convenient to point out the indications as to hygienic management and the promotion of sanitary welfare.

2. The human form or substance is made up of bones, muscles, tendons, ligaments, organs, arteries, veins, lymph-vessels, nerves, tissues, skin, hair, and nails. Of these, taking one hundred and fifty-four pounds as the average weight, the bones make about twenty-four pounds.

They are of shapes and sizes suited for the various purposes for which they are intended. As spoken of together, they form the **skeleton**. They are united by ligaments and cartilages. The number of bones is differently stated, accordingly as some which at an early period of life are separated become united, or as some very small bones allied to cartilage are classified with them. Some also include **the teeth,** while others name them separately

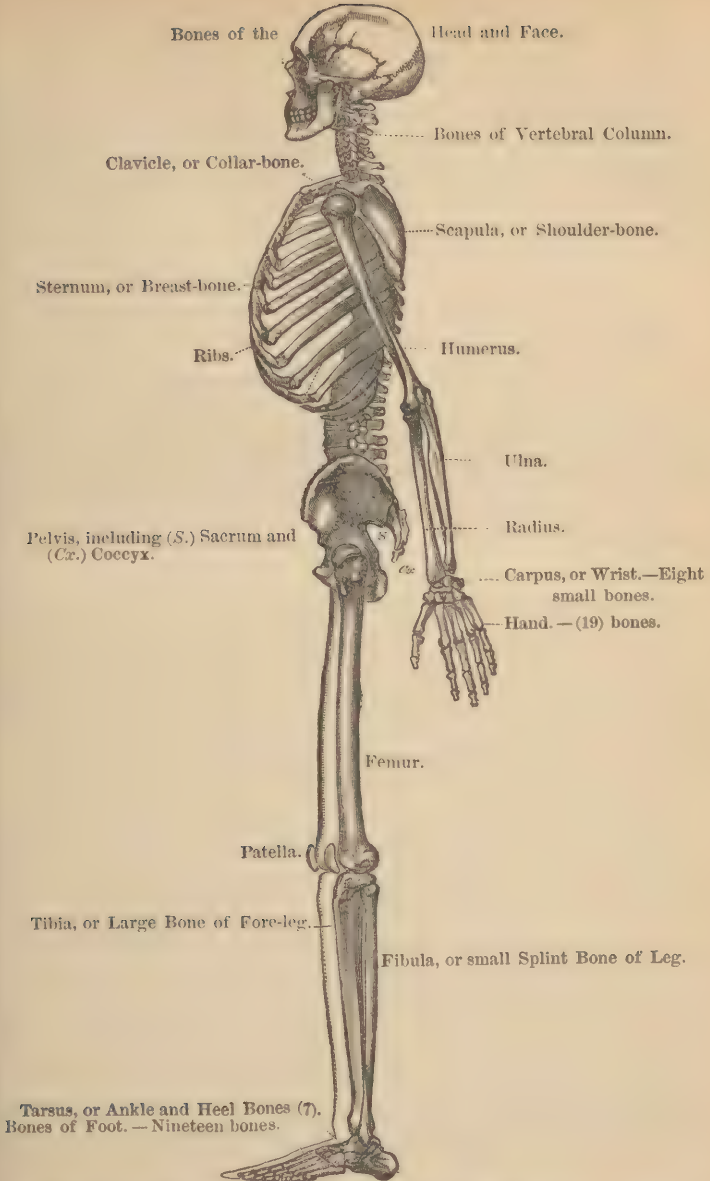


FIG. III.—The Human Skeleton, showing position of bones.

as a special form of bony structure. The number as thus given varies from two hundred to two hundred and fourteen, or to two hundred and forty-six if the thirty-two permanent teeth are included. The bones differ in shape and hardness, and are variously penetrated by blood-vessels and nerves. During growth **hardening** is not complete. Except where there is articular cartilage for joints or motion, the bones are covered with a thin, tough, vascular membrane known as the **periosteum,** or bone-covering. Sometimes, when a bone is severely bruised, without being broken, it sets up inflammation in this covering, and a variety of **felon** results, which is very painful.

3. The bones are the principal **levers,** which so co-operate as to support the body erect, and which, through the distribution and action of manifold muscles, secure for it its power of motion and the exercise of force. The accompanying skeleton in profile, and the parts as given therewith, show the relations of these various bones, and how they unite to make up the bony structure. Also the front view of the **scapula,** or shoulder-blade, the **thorax,** or chest, the **pelvis,** and the spinal **vertebræ** shows more fully their individual shapes.

The bones which form the **head** are at first eight in number, and so joined as to admit of compression, motion, and change of shape; but as the brain which they cover grows, and as the head needs more protection, they come to be solidified into one arch of solid bone.

Of the fourteen bones which are usually spoken of as those of the face, the two **nasal** bones which form the bridge of the nose, the two **malar** or cheek-bones, and the **lower maxillary,** or jaw-bone, chiefly give form to the face.

The bones of the back or **spine** are so arranged as to fit

one upon another, and admit of motion, by which, without much change in any one, and by the action of all, the body is flexible, and can be bent forward and to the side,

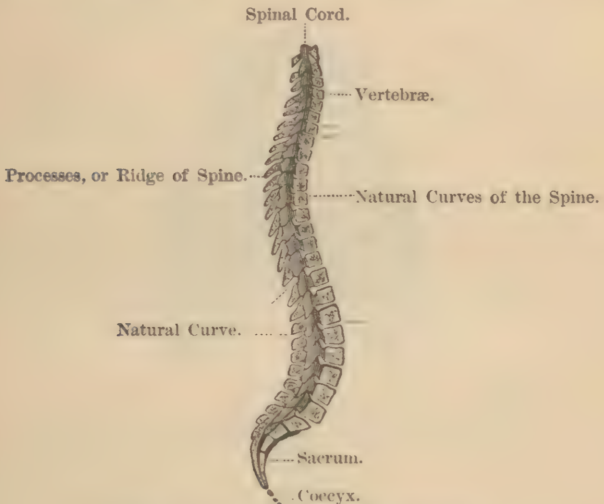


FIG. IV.—The Vertebral Column.

and to a degree backward, without injury. Five of the lower vertebræ of the backbone unite to form the **sacrum,** and four more to form the **coccyx,** or end of the vertebral column.

4. The bones of the **chest** admit of free motion for breathing and for other purposes. These are the **sternum,** or breast-bone, the **ribs** and the vertebræ, to which they are joined.

The bones of the **arms** and **legs** are so arranged as to secure free motion in many directions. Thus the **humerus,** or upper arm, with its round joint, and the **radius** and

ulna of the lower arm, securing a rolling motion, with the eight small bones of the wrist, and the nineteen of each hand, give great facility of movement. The **shoulder-bone**, or **scapula**, is remarkable in that the muscles, with

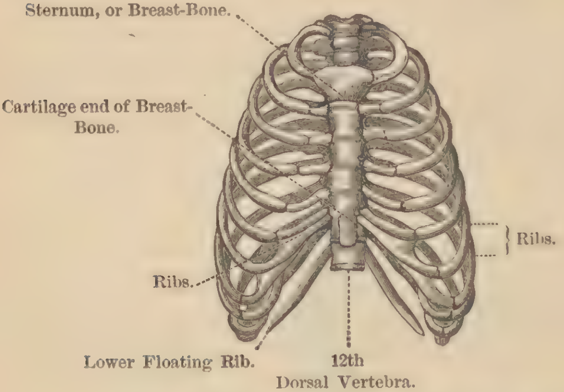


FIG. V.—The Bones of the Human Thorax.

only the aid of a single slight bone, the **clavicle**, or collar-bone as a **brace**, are able to give it firmness of position, and yet secure for it that mobility which makes it, with

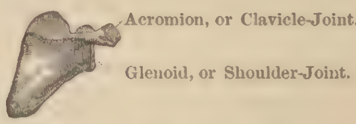


FIG. VI.—The Scapula, or Shoulder-Bone.

the arm, the forearm, and the hand, the most wonderful machine the world has ever known.

The **pelvis** (Lat. *a basin*) is the irregular hollow bone forming the lower part of the body, which supports the

contents of the abdomen, and transmits the weight of the body to the lower limbs. It is formed by the union of

FIG. VII.—The Pelvis.

the two large side or hip bones with the **sacrum** and the **coccyx**. The lower limbs, made up of the **femur** or long bone, and the **tibia** and **fibula** with the **patella** as the knee-

FIG. VIII.—The Left Tibia and Fibula and Patella.

cap, give firmness and yet great mobility to the body. Thus the weight of the body is transmitted to the **foot** with its elongated heel and its arch of bones.

5. A few of the bones are worthy of special notice, because of their more manifest and skillful adaptation to

particular uses. Thus, as we shall see, the bones of the interior of the **ear** are arranged to move loosely and readily on each other to aid in promoting sound. The bone which supports the tongue (**hyoid** bone) is firm, and yet itself movable and not fastened to other bones. The lower jaw is set at such relation to the upper as to secure great force when, by the action of muscles, pressure is sought to be made against the upper jaw for the mastication of food. The **ribs** are adjusted to each other so as to rise upward and forward, and recede downward and backward instead of in a direct line.

6. The bones of the **forearm** are so fixed as to give rotary as well as angular motion. This is accomplished by the **radius** or outer bone being small at the elbow, and yet forming the chief part of the joint at the wrist, while on the other hand the **ulna** or inner bone forms the joint at the elbow, and in its turn has but a small size at the wrist. These are so bound together by bands and ligaments, and so moved by muscles as to allow a variety of movement unsurpassed in any human mechanism.

The **wrist** and **ankle** bones are many in number, so as to give freedom of motion, and yet are very firmly bound together. The bones of the **hand** are so related to each other, and the thumb to the hands and fingers, as to secure mobility and strength. The **patella,** or loose bone over the knee, is located in the tendon of a muscle so as to give mobility, and yet secure a direction of force and greater power. The **foot,** by its shape, secures the strength of an **arch,** and yet a mobility essential for its variety of work. These but illustrate great varieties of adaptation and design, constantly apparent in the study of structure.

The bones are united to each other by **joints** of various

kinds, such as the broad or hinge-joint at the elbow, or the ball-and-socket joint of the thigh-bone, and by great varieties of modification of these suited to particular localities and uses.

7. Hygiene is greatly concerned in recognizing the perfect adaptation of parts and in enforcing those rules which preserve the bony structure and secure for it its best capacity. When we find how accurately each part is adapted to its work, and how all the parts as joined together co-operate for the one purpose of life and health, we are the more easily led to avoid deviations and infringements.

It is the province of Hygiene to teach how bones are (*a*) to have their proper nutriment, (*b*) to be preserved from distortion by improper posture, exercise, or management, and (*c*) to be protected from injury by accident.

For their proper nutriment the body should receive such **food**, both as to quality and quantity, as contains the materials of which they are composed, or such as the organs of the body are able to convert into such material. What these are will appear when we come to study the foods adapted to the human system.

For preservation from distortion, it must, first of all, be remembered that, although bones seem firm, they are capable of becoming **distorted**, or may suffer in **nutrition**, by the use of food deficient in the properties they need. They may also become bent or deformed by mechanical means. Pressure on the bone of the forehead has caused a tribe of people to be known as flat-head Indians. Pressure on the bones of the foot has made the Chinese noted for their compressed feet, and has injured the gait and comfort of many other people.

8. Carelessness as to **posture** in sitting, standing, or walking has often caused curvature of the spine, and thus greatly interfered with that adjustment of cones and pyramids which it forms and which sustains the spinal column. Careful examination shows that the spinal cord is made up of three distinct pyramids joining each other and having great accuracy of adjustment. It also has a cervical curve forward and a dorsal or sacral curve backward. Desks and tables, chairs, and other seats need to be of size and shape suited to those who are to make use of them.

It is to be borne in mind that the prevention of distortion also depends much on the **condition** and **use** of the muscles and tendons and ligaments attached to the various bones, to be considered hereafter. We have distortion of the bones and the muscles illustrated in what is known as pigeon-breast or hollow-breast, where the shape of the thorax has been changed by position or pressure. Drooping shoulders or bowed limbs are often the result of habit or dress, and can generally be corrected during youth. If not, the contour of the bones is disturbed, arches or columns lose their symmetry and spinal curvature or other forms of one-sidedness occur. Although the **deformities** made by habit or by fashion are not confined to bones, a notice of a few of these habits will illustrate how subversive they are of all laws of health, and of the most perfect use of the animal mechanism.

9. It is not necessary to refer to the extremes of these deformities, as found in a few very barbarous tribes where cutting of the flesh as well as deformity of the bones has been carried to a great extent.

The teeth are often deformed by art. Among some African tribes a triangular piece is filed away between each of the central incisors, or front teeth, and so a gap made in the middle of the front row. A recent writer has shown how the thumb-sucking of children will produce change in the shape of the lower lip and in the form of the lower jaw and teeth. This and other like habits

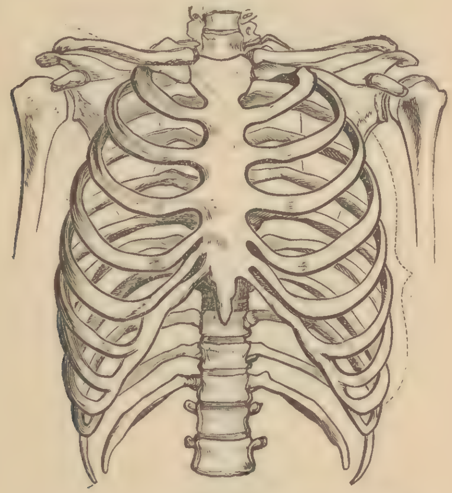


FIG. IX. — Thorax: Natural shape.

account for a pointed chin and other changes in the lower jaw, as inherited by children. In collections, many skulls are to be found, — as those of the Chinook Indians of the neighborhood of the Columbia river, and the Quinchuas of Peru, — which show depressed foreheads and elongated heads caused by systematic pressure.

10. How the **thorax** and all that constitute the chest

and waist has suffered, is shown by the comparison of two such figures as these, although the unnatural one is presented as by no means an extreme case. Unnatural pressure in the region of the diaphragm is not unusual in both sexes. Change of the natural shape of the waist by tight-lacing and systematic compression of the ribs

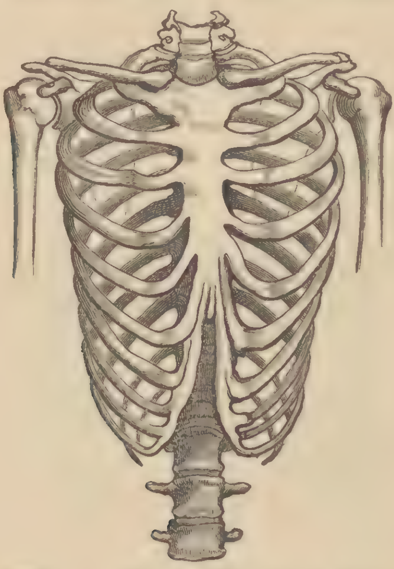


FIG. X.—Thorax: Unnatural shape.

not only interferes with the free action of the lungs, but is an embarrassment to the functions of several of the most important organs concerned in digestion. It also interferes with the remarkable nervous distribution in the vicinity of the stomach, and in too many cases has been the incipient cause of those nervous conditions too often found in those who would otherwise have been free there-

from. Tight **waist-bands**, or the carrying of a large amount of clothing suspended from the hips, is also objectionable. While the sides of the large bone of the pelvis are well adapted for the bearing of some weight, if so adjusted as to fall there, great advantage is gained by dividing weight with the shoulder by means of straps or elastic bands. The processes of life conducted by the vital organs of the body are too essential for us to trespass

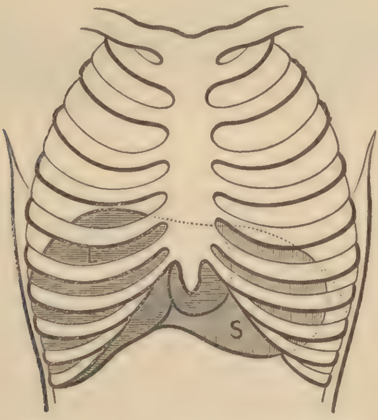


FIG. XI.—*L*, Liver. *S*, Stomach.

upon them by any of those external appliances which tend to compress them or to interfere with natural freedom of motion. This figure shows the situation of some of these organs.

11. These are examples of common deformities.

The narrow boots or shoes of men which tend to cramp the foot and compress the toes are even surpassed by some forms of ladies' shoes.

How the human foot has suffered, even in Christian lands, the following figures will illustrate: —

FIG. XII. — Foot, Natural Shape.

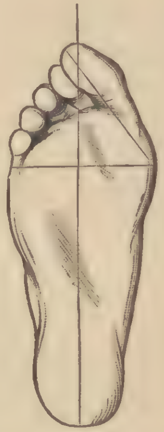


FIG. XIII. — Foot Deformed.

12. In the action of walking, the foot expands in length and breadth; in length often as much as one tenth, in breadth even more. Shoes should be made right and left. The heel should be low and broad, so that the weight is not thrown on the toes, and so that the gastrocnemii and solei, or leg muscles, can act, which they cannot do with a high heel. The broad, flat heel gives a good base for the column which forms the line from the center of gravity. The inner line of the shoe should be made so straight as not to push outward the great toe in the least degree. For marching boots, a slight bulge is often made over the base of the great toe, to allow easy play for the large joint. While the instep may be snug, room must be left for the fore part of the foot as it touches

the ground, and for the toes, which have important power of adjustment, and were never meant to overlap each other. They are the terminal **springs** of the foot.

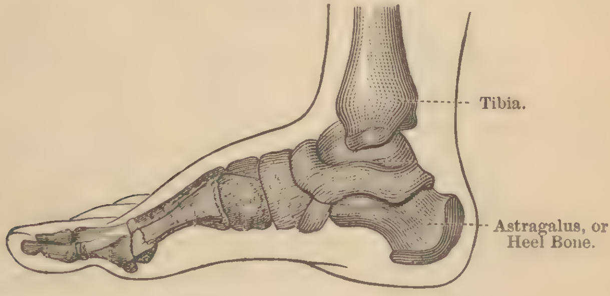


FIG. XIV.—Showing Bones of the Foot and Ankle.

The relations of the foot as an arch to bear up the body, and to give elasticity of motion of parts, are here shown.

13. **Deformities** of the pelvis are sometimes caused by modes of standing or sitting or walking in childhood. Some persons show such defect of solidity in bones, or such weakness in the ligaments and muscles about them, that, when the bones do not break, they bend in various shapes and cause deformity. This is to be remedied in part by exercise and proper food. While formation and growth are natural processes, we are ever to bear in mind that we have great control over them. As in the system of the natural world, so in the human system, we can do much to determine form and strength. We must see to it that the body in all its parts has the best chance for perfection, and especially that the bony framework does not become changed beyond the reach of repair.

Chapter VI.

MUSCLES.—BODILY EXERCISES.—CALISTHENICS.

MUSCLES are bundles of fiber which have contractility, or power of shortening under the command of the will, or under influences independent of the will. When these influences are suspended, they return to their original place and shape.

Muscles are of two classes, **voluntary** and **involuntary**; or those subject to the control of the will, and those acting under some other form of stimulus. The first class form the bulk of the muscles, and are chiefly distributed to the bony framework. The second are chiefly within the cavities of the body, and have to do with the vital processes of circulation, respiration, digestion, etc.

We have first to do with the **voluntary** muscles. They make up in weight about forty-four per cent of the body. These are chiefly intended to direct and control the movements of the various bones, although occasionally there are muscles which by co-ordinate movements with or upon other muscles also accomplish change of direction or exert power. By placing one hand around the larger muscle of the upper arm, and moving the forearm backward and forward, one may obtain an idea of muscular power and action. This figure of the forearm furnishes an example of how muscles of various sizes and shapes are formed, and by their tendons attached to bones. As the muscles are usually attached to bones, and act as so

many levers or strings to pull them one way or another, they may even come to be means of deforming bones. When a bone is out of its line of direction, or broken, they serve to draw it still more out of its place, and so occasion much pain.

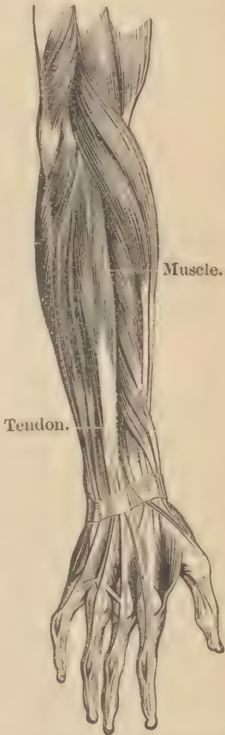


FIG. XV.—Left Forearm.

2. These muscles depend for their strength upon the general condition of health, upon food proper in quality and quantity, and upon such exercise and use or training as are found to develop and strengthen them. Thus the muscle in the arm of the blacksmith becomes, by his vocation, developed into a size and power beyond what would be the direct result of proper food and good health. As the bony structure depends much for its right position and power upon the good condition of muscles which are co-operative with or essential to each other, we are never to lose sight of the dependency of the one upon the other. In all these studies of different parts of the human mechanism, while parts are capable of special development and vigor, it is to be borne in mind that **all parts** are more or less dependent on each other, and that, as a rule, the perfection of any local part is not possible without a good condition of the whole system.

3. **Tendons,** or sinews (Lat. *tendere, to stretch*) are the inelastic white cords by which muscles are attached to the bones. They are really the connective tissue, or thin sheath which covers the muscle extended to the bone or attachment-point, so as to form a tendon. Thus, by placing the hand at the back part of the ankle, just above the heel, and moving the muscle of the leg, you may feel the *tendo Achilles,* which is the tendon of a large muscle of the leg, and is attached to the heel-bone.

4. **Ligaments** (Lat. *ligare, to bind*) are the tough bands, or strings of white fibrous material, by which bones, intended for more or less movement, are held closely enough in place not to allow of their slipping out of place under ordinary circumstances. When there is such a slip, it is called a **dislocation.** When there is a severe pulling or twisting, which does not displace any bone, but strains the ligaments, it is called a **sprain.** When this kind of substance is much strained, it is generally slow to recover. The term **dislocation** is chiefly applied to bones when out of place; but sometimes a large ligament is thrown out of place more than in a sprain, and is said to be dislocated. When there is the breaking of a bone, it is called a **fracture.** Bones, where they meet for **joints** or motion, are enclosed or covered with a tissue or substance called **synovial** membrane, which secretes a slippery fluid to prevent friction. Then the ligaments are bound about or over this. When the substance is a little harder or more dense than the tendon or ligament, it is called **cartilage,** or gristle. Bones themselves may be said to be cartilage, or connective tissue, hardened by being united with lime or other mineral ingredients.

5. As with bones so with **muscles,** their general vigor de-

pends upon the welfare of the whole system. Yet muscles and sets of muscles admit of special care and training. It is to be borne in mind that many muscles are intended to co-operate with and assist each other, while others are for purposes directly opposite. Thus, when we chew food, there are several muscles of different forms and shapes that bring the lower jaw against the upper. When we bend the forearm upon the arm, there is a class of muscles called **flexors**, on the front of the arm, that bring it into this position. When we desire to straighten it again, there is another class on the back of the arm, called **extensors**, that enable us to extend it at full length. There are, again, muscles on each side of the body that are the analogues or complements of each other, as those each side of the breast-bone and between the ribs, or those running along each side of the back. The erect position on two feet, which seems so natural, results from the adjustment of a multitude of muscles which co-ordinate or balance each other. It is our power over their action, and the quickness of its exercise, that enables us to keep the center of gravity and to change it so often. It is possible to develop one class of muscles so much as to make one side of the body much stronger than the other, and so make us lop-sided.

6. Thus the bones themselves may be drawn from their exact shape and position by a too constant action of one set of muscles. We sometimes see the effect of this in those who, very early in life, occupy a wrong position in play, work, or study. It is surprising how often exact measurements reveal the fact that persons who have not been aware of any lack of symmetry of either side are found to vary more or less from a perfect standard. Both

health, power, and grace of motion depend much upon a developed or preserved symmetry, for which the skeleton and its muscles are well adapted.

7. **Exercise** is of importance because it is **education.** All true education is that which secures healthful development. There is constantly going on in the human system a process of decay and renewal, a using up of force, and a production of new force from materials furnished. **Thought** as well as bodily exertion causes waste of material, and demands resupply. Life and health are always dependent upon this relationship of demand and waste, and of supply to the reinvigoration or resupply of the material needed for the continuance, not only of work, but of the process of living. Within limits, nature has great resources of adjustment and compensation, and when deprived of her supply by overwork, or by too tardy resupply, will still avail herself of various means within the system. But this is only temporary, and is always a tax on vital force.

8. It is because exercise has so much to do with the destruction and renewal of the body, that it becomes an essential consideration. **Exercise** is the chief agent in the renovation of tissue, and is needful because in the processes of life all tissue is undergoing destruction. It quickens the circulation of the blood, which is the remover of waste and the bearer of nourishing material. It especially aids the action of the minute blood-vessels or capillaries. It, therefore, not only quickens the activity of circulation, but also that of the **involuntary muscles** which have to do with the inspiration and expiration of air. The influence of increased circulation and respiration is felt in all the organs, and

so digestion and all natural secretion is promoted. To the persons in process of growth it is even more important, because, besides supplying daily waste, it is contributing to development, and determining the size, functions, powers, and habits of the whole body.

9. While **exercise** is primarily the use and movement of the voluntary muscles, it includes far more than this. It is their use in such way as to affect the whole system. By it, the activity of all voluntary muscles, and to some extent of the involuntary muscles, and the activity of the functions of all organs, are more or less determined. Exercise influences the rapidity of action in the lungs, the heart, and other vital parts. The functional **ability** of every organ is in relation to its **activity,** or is affected thereby.

10. **Modes of exercise** are fundamental in their influence, since not mere motion, but such motion as affects also involuntary muscles to some degree, and such as affect organs and their functions, is essential. As exercise also has a relation to the outer world, and brings the powers of the body either into co-action with or antagonism to other powers, it must be adapted to these co-operations or antagonisms. Thus, walking up a hill or stairs, or carrying a weight, or pushing as distinct from pulling, are specimens of modes of exercise called out by motion amid other forces.

11. We are to learn much as to **exercise,** or the use of muscles, from the methods that are natural. We find all muscular action is intermittent, and that much of it is interchangeable. Parts are relieved not only by alternation, contraction, and rest, but also by the fact that one set of muscles often relieves the other by compensating

for their tardy work, or by quite directly substituting their work or by resting disabled parts.

So great is this influence of exercise over the involuntary muscles, over respiration, circulation, perspiration, secretions, and all forms of organic or functional action, that, while the human system has a perfect apparatus for life, it is dependent upon the aid of exercise for its efficient operation and proper continuance. Not only the heart, but all the vessels, are so responsive to the influence of work, or use, that they have been called "hollow muscles," since all these innumerable ducts have a contractile or elastic power, which, like the heart, is affected more or less by exercise.

While the ability of bodily exercise depends on the muscular and respiratory systems these, in their turn, are much affected as to vigor and efficiency by exercise. Therefore, if asked what exercise does, the reply is:

12. (*a*) It increases the size and power of the voluntary muscles employed.

(*b*) It increases the functional capacity of the involuntary muscles employed.

(*c*) It promotes the health and strength of the whole body by increasing respiration, quickening circulation, and sending more blood through the minute vessels of the organs and the minute vessels of the skin. It has a broader and more useful service when guided by a knowledge of anatomy and physiology, since it can be made to aid those who are of a weak organization, or who, because of accident or neglect, need repair or reconstruction. It is well to have great physical strength, but this is not indispensable, since there may be symmetry and good health without it.

(*d*) Exercise may preserve or recover health where it does not impart great strength. Indeed, there is a distinction between that kind of exercise which is intended to fit a person to exert great muscular force, or to perform some feat with a class of muscles, and that which is merely intended to sustain a general vigor of constitution, and to fit one for the ordinary duties of life.

More attention is now being given to what is called **body-building,** or a general and equable development of all the parts, than to mere muscular training.

(*e*) We are to adapt exercise to persons, to circumstances, and to conditions, and sometimes to particular organs that show lack of development or vigor. To over-develop a set of muscles, as those of the arm for great lifting, does not always include a strengthening of the whole framework. It is **body-building** we need; we are to seek such vital capacity, such adjustment of all the parts, as will best sustain the whole. Many a person loses health because there is a defect in one vital part even when all the rest of the system is in good condition. The strength of a chain is to be estimated by that of its weakest link, and this is too often the case as to the strength of the body. Where we cannot fully repair or bring a person fully up to a standard of health, we can study the **type** of the individual, and bring him up to a higher standard of comfort and vigor. We use the resources we have to acquire more. All do not begin with the same **capital of health,** or even acquire it, but they can, at least, learn what their capital is, and its ability of preservation or increase, and live accordingly.

13. Hence, while we can give some general rules or announce some general principles as to exercise, there are

details which need adaptation to individual cases. Exercise should be regulated by individual fitness, and should be gradually increased with increasing strength. Hence the art often needs, like any other instruction, to be taught by those who have knowledge, and who, by practice, have learned to discern the indications. It cannot all be taught by books.

14. Health is not the mere vigor of the present, but the power to **work long,** to **work well,** and to endure unto the end. For this, one needs not only strength for the daily routine of life, but such as will give reaction and recuperation from the strain and fatigue which, with all our caution, is pretty sure now and then to overtake one who attempts to meet the work and responsibilities of life. All this requires a thorough appreciation of **physical education** in school life, and a thorough course of instruction therein.

15. There are a few rules as to exercise which, with this understanding, may serve as general guides. Some references to particular exercises may aid those who cannot fully avail themselves of teachers.

Very active exercise should not be taken just after a full meal. The reason of this is, that the supply of vital force is generally diminished just before a needed meal, and that digestion itself, in its first processes, has not yet refurnished the system. Observation shows us that most animals incline to quiet immediately after eating.

Active exercise before breakfast is not generally beneficial. No doubt it may be advantageous to such as have large vital force; but experiment shows that it is better, after so long a fast, to take some nourishment before exercise.

16. The forms of exercise most to be relied upon by those in good health, and who are not seeking to remedy any special disability, are such as bring into play the most of the voluntary muscles used for change of place.

Walking is a specimen of natural exercise, and, like some others, has this advantage, that it also gives us change of air and change of scene. On the other hand, **stair-climbing** is a form of unnatural exercise, which, if frequent and long continued, is an injury to many, and especially in schools. The most uniform **rule** as to the extent and degree of exercise is that it shall continue until there is a feeling of glow or warmth of surface, or a slight perspiration. Exercise may be carried beyond this without harm, as is often necessary in work, and of advantage during the process of growth. But the **value** of exercise, as such, is generally reached when there is glow and slight perspiration. A feeling of fatigue is always an indication of a needed, partial or continued rest, or a change as to the mode of exercise.

The kinds of exercise needed for special ailments or defects are to be recognized as quite distinct from those for the general educational benefit of the whole body. Thus the Swedish or Ling and the Zander systems are especially adapted to those who are below their usual vigor, while the McLaren, Spencer, and Sargent systems are for general service.

Bathing is to be recognized as an important **exercise**, inasmuch as much of its benefit is derived from the stripping, rubbing, and oiling, the sun-bath and manipulation which may be used therewith. Indeed, for many it is to be ranked more as an exercise than anything else.

Exercise should always be taken where the **ventilation**

is good. As all active movements tend to increase the amount of air inhaled, it is important that it be not contaminated in any wise.

Natural breathing, as opposed to holding the breath, is important during all exercise, and such deliberation as prevents all unnecessary straining to accomplish the object sought.

17. **Special Aids to Exercise, — Athletics, Gymnastics, Calisthenics.** — In order that the body may receive proper exercise, that the bones and the muscles attached to them may be kept in the best order, and the various organs be aided in their functions, resort is had to various artificial systems, especially for the discipline of voluntary motion. These are known as athletics, gymnastics, and calisthenics. **Athletics** refers chiefly to games or methods of skill practiced for contest, and exercise such as wrestling, boxing, fencing, jumping, running, riding, ball-playing, skating, quoits, golf, rowing, etc. Archery, croquet, lawn-tennis, and the allied games of la-crosse, fives and racket, have made a very valuable addition to out-of-door athletics, so that girls as well as boys have increased opportunities for recreating exercises.

The **saw** is a convenient means of exercise. Have a high bench, with a large vise fastened upon it to hold the stick of wood. Then use a common coarse hand-saw, or use one in each hand. It preserves posture, and is an exercise very available for girls as well as boys. It is inexpensive, and many a girl can thus secure chest and muscle development and great benefit to general health.

18. **Gymnastics**, among the Greeks, denoted various out-of-door methods of exercise in which the gymnast appeared with little clothing for feats and exertions show-

ing vigor, courage, and skill, and developing physical power. This training was considered so important, that it came to express the entire course of education. So in Germany the elementary and high schools are called gymnasia. In athletics and gymnastics, only such clothing is desirable as taste requires, and such as shall not by weight, stiffness, or warmth interfere with freedom of motion.

In gymnastics, the most prominent mechanical aids are the **horizontal bars,** the **parallel bars,** the **vaulting-horse,** the **ropes and rings,** and **the flying trapeze.** In all these there is need of special instruction and of studying the adaptation of age and constitution. In all more active exercises, while the person should rely mostly on a loose flannel suit, wraps to moderate the rapidity of cooling, and to protect from draught or change of temperature, are quite necessary.

19. In most of those exercises which are termed **recreative,** while the occupancy of attention and the skill acquired are excellent, yet much that is educational is lost sight of. In most of these exercises the right arm and the lower limbs are so much more used than the rest of the body, that they are trained out of harmony with, or sometimes at the expense of, other parts. After the body is full grown, and all the parts have acquired due form and power, this kind of exercise is not apt to go so far as to distort. But in the training of youth, the recreative idea should be in subjection to the educational, and constant effort be made to develop the wholeness of one's self. This means that respiration, blood circulation, nutrition, and waste should be studied very closely, and that exercise should have regard to these more than to mere

growth of muscle. When these are assisted in the process of growth, and by due course of training, ordinary recreative exercise and prudence quite suffice to maintain them.

20. **Calisthenics** relates to those forms of exercise used as a system for the development of parts of the body, or for general exercise, independent of mechanical contrivance. Such are rhymthic movements of the limbs, — musical, vocal, and parlor or school-room manual exercises. The word *calisthenics* means **beauty and strength,** and the practice of calisthenics secures both grace of movement and vigor of physique by means of rhythmic exercises.

21. Some of the feats called gymnastic, and various forms of athletics, are exhibits of skill and art at the expense of health. In all forms of exercise, we must find the basis in the demands which the anatomy and physiology of the human system indicate, or those special demands which departure from the anatomy (deformity or deficient development) and disturbance of physiology (*pathology*, or imperfect function) indicate. The teachings obtained by experience, or as the results secured from various kinds of bodily discipline, are also a guide. There are so many persons not born with perfect conditions for health, or not in early life having all the advantages for perfectness of form and of function, that very many are benefited by modes of exercise skillfully adapted to their needs. Every motion should be fully achieved sooner or later, according to capacity or increase of strength.

22. In calisthenics much service can be done by manual movements in the school-room which give change of posture, which rest for a few moments from study, and which give at the same time pleasure and recreation. Often, too,

a school-room can be aired during the active exercise of the pupils, when they would feel chilly if inactive or in a sitting posture. Pupils, while studying their lessons at home, may pause five minutes in each half-hour, and not really lose any time. The muscles are rested and the system refreshed by a change of seat or of position.

For a knowledge of calisthenics, or of light gymnastics, such brief manuals as that of Prof. J. M. Watson, or the Home Gymnastics of Hartelius (Lippincott & Co.), or the Gymnastic Free Exercises of Ling and Roth (Balliere, New York), or the Code-Book of Puritz (Trübner, London), will give all needed instruction. These furnish examples of movements applicable to all parts of the body, which may be accompanied by music, and by the use of light apparatus.

23. In connection with calisthenics, or light gymnastics, it is well to employ some of the well-known forms of hand apparatus. Hand exercises are conducted with a simple wand or bar, which may be round or slightly rectangular, and of about two inches or less in diameter. These are of great aid in many movements.

Hand-rings made of cherry or walnut, polished, admit of considerable use in pulling exercises, or where the two hands are needed to be kept in parallel position.

Dumb-bells, in all their various sizes and weights and lengths, are of important service in developing muscles, and for the general invigoration of those of sedentary habits. Beginners, as a rule, should use the wooden dumb-bells, which can now be had of various sizes and weights, and admit of most valuable use.

Besides the various motions and uses so fully described by authors, it is not difficult for any two or three persons,

or a class, to agree upon a series of movements, and thus give great variety of use.

We are indebted to the Orientals for the valuable aids to exercise known as the *Indian Clubs.* These come in long and short sizes, with diameter of handle and knob and entire weight proportioned to those of different ages and degrees of strength.

24. It is not necessary in this manual to note all the various devices, many of which admit of light use as well as of the more venturesome feats. Those who use the manual forms and the lighter apparatus will seek these if needed. But the calisthenics of the school-room or the small playground do not need more than those we have mentioned. Even to those accustomed to active exercise, they afford change and recreation, and both in the home and in the school serve to impress the relation of activity and of educated movement to grace of carriage as well as to robustness of health. While exercise needs to resemble actual labor in all its essential particulars, these modifications greatly aid those who pursue no manual industry, and by their order of movement aid in mental and moral as well as physical culture.

For all these and other exercises it is to be recognized that there must be a corresponding attention to proper food, to a proper use of the breathing apparatus, to a training of the senses, to sleep and rest, and to all those particulars which tend to keep the system in a proper condition to exert force.

Chapter VII.

THE SKIN, ITS FUNCTIONS AND ITS CARE.

NEXT to some knowledge of the bones and the muscles, and their immediate attachments, as related to healthy care and use, we pass to a notice of the coverings drawn over these which are in closer contact with our surroundings. The muscles are sheathed in what is called **connective tissue,** which is continued to the end of the tendons. It passes from the true skin to all the other parts, and is known as the areolar (Lat. *areola, a small, open space*) or elastic, fibrous, or cellular tissue. Tissue (Lat. *texere, to weave*) is a general word to denote organized membranous structure or material. It varies in the aspect of its **nuclei,** or cells. So various modifications result, and it is called **areolar, cellular,** or **fatty** tissue, from the variations in the form of the cells which are interposed in its meshes.

The tissue just beneath the skin is oftenest spoken of as **areolar** tissue, and by fat and other deposits is modified as to its network, thickness, and structure.

2. Over this, and indeed as a kind of modification thereof, we have the **skin** or integument which covers the whole body. At some points, as the lips, it shades off into a similar but more delicate layer, which is redder, and is kept moist by giving out a slightly viscid fluid. This gives to it the name of mucous membrane. This may be called the skin of the internal body. The general

outer skin or **integument** is made up of two parts, the **epidermis** and the **dermis** or true skin, "**cutis vera.**" The epidermis is really but a hardened secretion from the dermis, or true skin, without vessels or nerves. As it can be raised, as in a blister, and separated from the true skin, it is convenient to speak of it as the epidermis, or upper layer. The upper cells thicken and become hard on pressure. Its lower surface is a little softer, and in it are the pigmentary cells in which the coloring matter of the skin is developed or deposited. This determines the color or **complexion.** The **corium,** or deeper structure, consists of strong intertwining fibrous bands, amid which are nerves, lymphatics, blood-vessels, fatty tissue, hair-follicles, sweat-glands, oil-glands, nerve papillæ, etc.

A **gland** is an organ whose function is that of secretion or excretion, or both combined, and which contains ducts or vessels for the escape of matter elaborated or excreted by the gland. These **ducts** pass through the epidermis and open upon it.

3. The sudoriferous (Lat. *sudor, sweat,* and *ferre, to furnish*) or sweat-glands, situated in the **dermis** or corium, have each their minute convoluted and spiral tubes or ducts, and are so numerous that if extended in one line they would make a length of about 2½ miles. Krause estimates their number at 2,381,248. Says Huxley: "They are fewest in the back and neck, where their number is not much more than 400 to a square inch. They are more numerous on the skin of the palm and sole, where their apertures follow the ridges visible on the skin, and amount to between 2,000 and 3,000 to the square inch. At a rough estimate, the whole integument probably possesses not fewer than from two millions and

a quarter to two millions and a half of these tubules, which therefore must possess a very great aggregate of excretive power." Without these glands and their tubules there would be some **perspiration.** The skin would be in the position of a moderately thick, permeable membrane interposed between a hot fluid, the blood, and the atmosphere. Thus some perspiration would be going on from this structural condition, but it would be only slight without the sweat-glands. These and their tubes are so interposed amid the thin walls of the capillaries as to be sure to receive therefrom by transudation.

4. Besides, or connected with their functions as **excretory organs,** their great function is to regulate the **heat** of the body. As the heat of the body is raised by the oxidation of the food, which is greatly increased by exercise or by exposure to extreme heat, a part of it is made latent by the conversion of the water into vapor in these sudoriferous ducts. It passes off from the skin as insensible perspiration, but is often condensed on the skin as sensible perspiration. The evaporation causes reduction of heat, and so regulates it. If persons long exposed to extreme heat cannot perspire there is always danger. A workman in the harvest-field was noticed to drink much water, but not to perspire as did the rest. A few hours after he fell with sunstroke, and died. The amount of insensible perspiration each day is from one and one half to two pounds avoirdupois.

5. The cutaneous **perspiration** is slightly acid, of faint odor, and contains saline matter, carbonic acid, and traces of lactic, formic, acetic, and butyric acids, with small quantities of sebaceous matter and epidermis and epithelial cells. The skin also slightly absorbs oxygen. Thus

frogs have lived several hours with the lungs removed. The quantity of carbonic acid is from one-thirtieth to one-sixtieth of that excreted by the lungs.

6. The **sweat-glands** are greatly affected as to their activity by heat and various atmospheric conditions, by the state of the blood, of internal organs, and of the nervous system. The **nerves** open and close the ducts, as the conditions of heat and cold may indicate, so that this safety-valve apparatus is operated by them. Mental emotion may cause either a sudden cessation or pouring out of perspiration. By cutaneous perspiration alone it has been found possible to reduce the weight of a man over two pounds in an hour. Thus by profuse sweating much solid matter in solution or minute suspension is eliminated from the system. Hence various forms of forced perspiration have been used to rid the system of effete or irritating materials, and to relieve congestion or change the abnormal structure and function of internal organs.

So important is the perspiratory power of the skin that of old the kidneys and the skin were called the common emunctories (Lat. *emungo*, *to blow out*). These organs were so named because they could forcibly pour out and separate from the system all unneeded, superfluous secretions.

7. The quantity of water excreted by the **skin** is in general about double that by the lungs. If the skin were kept for a time encased in an impermeable covering, as shellac or varnish, death would result. The whole amount of material thrown off from the skin daily is reckoned from 10,000 to 15,000 grains, varying somewhat according to various conditions.

The skin, with its different layers and glands, is shown by the accompanying cut.

8. The skin, the lungs, and the kidneys need to be regarded as associated or complementary organs.

They are the three chief organs of excretion.

FIG. XVI.—Vertical Section of the Skin.

"Different as these organs may be in appearance, they are constructed on one and the same principle. Each, in ultimate analysis, consists of a very thin **sheet of tissue**, like so much delicate blotting-paper, the one face of which is free, or lines a cavity in communication with the exterior of the body, while the other is in contact with the blood which is to be purified. The

excreted matters are, as it were, strained from the blood through this delicate layer of filtering-tissue, and on to its free surface, whence they make their escape.

"Each of these organs is especially concerned in the elimination of the chief waste products, — water, carbonic acid, and urea,—though it may at the same time be a means for the escape of the others. Thus the lungs are especially busied in getting rid of carbonic acid, but at the same time they give off a good deal of water. The duty of the kidneys is to excrete urea (together with other saline matters), but at the same time they pass away a large quantity of water, and a trifling amount of carbonic acid; while the skin gives off much water, some amount of carbonic acid and a quantity of saline matter, among which urea is sometimes present."

9. In twenty-four hours **the skin** throws off or excretes on an average 10,000 grains, or about eighteen ounces, of water; the lungs 5,000 grains, or nine ounces of water; the kidneys 24,000 grains, or about fifty ounces.

The **skin** throws off about 400 grains of carbonic acid in twenty-four hours, of solid matter 300 grains, and so is a direct auxiliary to the lungs. In disease it often can be made to do far more than this, and so relieves congestion.

10. Water is the largest excretion from the skin. More gaseous matter is given off by the lungs, and more solid matter (1,000 grains) by the kidneys. Through the lungs and the skin the body loses much of its liquid and gaseous matter. They are the only parts through which **oxygen** is introduced in the blood. The amount through the skin in man is not large, but it is accessory to the lungs. In some lower animals the skin contributes much to the

respiratory function. In general, it may be said that the skin partakes of the nature of both lungs and kidneys, seeing that it absorbs oxygen and exhales carbonic acid and water like the former, while it excretes organic and saline matter in solution like the latter. The animal heat is regulated by the skin and by the organs of circulation. The former keeps down the temperature through the agency of the **perspiration,** by which evaporation is promoted in a ratio proportionate to the surplus heat generated. Nothing tends to keep down the accumulation of heat more than evaporation, by which heat is rendered latent or insensible. It is thus that the skin regulates the animal heat in a Turkish bath, and that a live animal may live in a hot oven in which a dead one would be roasted. Our insensible and perceptible perspirations are the great **regulators** of internal heat, so that, however rich our foods may be in heat-producing qualities, the temperature of the body in a state of health is kept very evenly at 98.6° F.

11. The **sebaceous** or **oil-glands** (Lat. *sebum, suet*) are lodged abundantly in the surface of the corium, or deep skin. Each gland consists of a single bag or follicle of basement membrane lined with epithelium and ducts terminating in a pouchlike extremity, these having various forms. The ceruminous or wax-glands of the ear and the glands of the eyelids are of a similar kind. The number of sacculi connected with each duct varies from two to twenty. The orifices of the ducts open upon the surface, and are more numerous about the hair-follicles. They are intended to render the skin soft and pliable. The retention of sebaceous matter in these ducts, when of the larger size, gives rise to specks, as sometimes seen

upon the face. In the ear, its accumulation as cerumen or wax often causes partial deafness.

12. The **minute hairs** scattered in great numbers over the skin have their origin in a nerve-sac in the corium, or true skin. The sebaceous glands usually connect with the hair-sacs, and are lubricated there in the skin. These minute ducts are very numerous. The **lymphatics** (Lat. *lympha*, *water*), so called because carrying a watery-like fluid, are also sometimes called absorbents; from their ability of absorbing certain materials for replenishing the blood. These abound in an interlaced network in the upper portion of the corium, where they are intermingled with the capillary and nerve plexuses. The **nerves** are also spread about in the upper surface of the corium, with fine branches given off to the papillæ either as loops or some probably terminating in a free extremity. The minute blood-vessels enter amid the areola and interlacing fibers of the corium and divide into a capillary plexus (Lat. *plecto*, *to braid*), which feed the sweat and oil glands, etc. It is in the minute capillaries of the skin that we have the changes manifested by perspiration.

13. The various parts of the skin are abundantly supplied with blood-vessels, not only for local nourishment, but because the capillary system of which the skin is the container does such a great **excreting** work for the whole body. The arterial blood which started from the lungs has gathered up very much material needing to be disposed of before its return to the heart and the pulmonary circulation.

The conversion of arterial into venous blood takes place not only in the lungs, but in most of the **capillary vessels** of the body, and especially in that wonderful capillary

network of vessels found in the skin. A **clean, healthy skin** is therefore constantly aiding the lungs in supplying oxygen and removing used-up materials from the blood. Any serious derangement in the skin-tissue is quite likely to make itself felt upon the delicate pulmonary tissue.

14. Amid all the areolar network in the **corium** there are not only many blood-vessels, but from it an abundant nerve supply passes to the upper layer of the skin. The **corium** is only about one-tenth of an inch in thickness. When we have **cutis anserina,** or goose-skin (*horripilation*) it is owing to the contractility of the corium, or deeper tissue of the true skin about the hair-sacs. The alleged standing of "the hair on end," so far as true, is owing to this.

The papillary layer of the **cutis vera,** or true skin, consists of conical papillæ upon the free or outside surface of the corium. These consist of a convoluted nerve loop about one-hundredth of an inch in length, and of single or convoluted capillary loops. Both as to size and arrangement the papillæ differ, for while on the general surface they are small and quite evenly distributed, in sensitive parts, as the lips, hands, and feet, they increase in size and numbers. In those parts where sensation is very highly developed the nerve fiber has a little point within the papillæ, sometimes called a "tactile corpuscle," which seems somehow to add to the delicacy of the sense of perception. In some parts the **papillæ** are arranged in rows, or collected in small square-shaped masses. with a minute sweat-duct orifice in the center. It is to this kind of arrangement that the **lines** and **furrows** we see in the feet and hands are due, these being the parts between the rows of papillæ.

15. We have already noted how the skin and its glands have most important functions as to the circulation and its relation to the lungs, and the kidneys as excretory or separating organs. The **skin** is wonderfully endowed with **nerves**, and is greatly under their influence. In order to keep the circulatory, glandular, excretory, and combustive processes in proportion or physiological balance, the nervous system as distributed in the skin performs a most important work. Its relations to organs, to functions, to sensation, will, perception, secretion and excretion, circulation, and all physiological action, and to many disturbing or pathological processes, is such that, like a ready custodian, it is on the alert to provide for or prevent contingencies which may impair the welfare of the body. Some parts are more sensitive than others. Besides the general sensibility, it is made to subserve the special sense of touch. Experiments with the points of compasses, blunted with pointed pieces of cork, have enabled Weber and others to determine the various degrees of sensibility of different parts. Thus the two points of the compass can be distinguished from each other at a distance of one-twenty-fourth of an inch at the tip of the tongue, one-fourth of an inch at the tip of the nose, five-twelfths of an inch at the palm of the hand, at the tips of the fingers one-twelfth of an inch, and five-sixths of an inch on the forehead.

16. Upon the **dermis** is a superficial layer composed of minute particles which are being constantly shed off in scales or scarf-skin and as rapidly reproduced. This latter is called the **epidermis**. It is seen separate when by some irritant, as a burn, a blister is raised.

This epidermis, cuticle, or scarf-skin is accurately mod-

elled on the papillary layer of the **cutis vera**, or true skin, and may also be spoken of as of two parts, namely, the epidermis proper and the **rete mucosum**, or (*mucous, net*, L.) membrane containing the coloring-matter. The color is dependent upon pigment, or coloring-matter in the cells, just as we have it similarly in the choroid coat of the eye and in the different colors of hair. Were it not for the epidermis, the skin would absorb too readily, for we see, if we remove it, as by a blister, how quickly any substance sprinkled over it enters into the circulation. The external or denser surface of the epidermis consists mostly of thin scales, and being subjected to friction they are flattened and made harder and desquamated; hence they are constantly falling off.

Then, again, as in the case of workmen, or in exposed parts, the epidermis thickens, and so protects the hands, feet, and other surfaces. Where there is too much pressure, or friction long continued, it becomes hardened by pressure into successive layers, the upper ones being broader than the lower, and so a kind of cone or peg is formed, with its apex downward. So **corns** are formed, and come to be very troublesome, and so also **bunions** and various results of this pressure and friction occur. Thus the thickening which is intended on the hands, feet, and other exposed points, and at the flexure of joints, to protect, becomes by over use or abuse a source of pain.

17. Some idea of the amount of the loose epidermis, and of its quick reproduction, can be formed by soaking the feet, and then removing all the scarf-skin that can be rubbed or scraped off, and looking at it under a microscope. Those who have to be engaged in kinds of work that subject one spot to great friction do well, by oil and

by covering, to afford special protection. Corns and bunions are avoided by a perfect fit of shoe. When there are the first evidences of undue friction, a softening of the part by warm water and frequent oiling, or the use of a borax-wash, will help to prevent subsequent irritation. All loose skin that can be easily removed should be scraped off with a smooth, hard edge, and the shoe that is very tight, or so loose as to constantly rub against parts of the foot, should give place to one that fits.

18. The **hair** is essentially epidermis, composed of coalesced cells inclosed in a kind of sac, with a **papillæ.** The hair is developed by the superficial cells coating the papilla being adjusted one upon another so as to form a shaft or continuous extension of epidermic cells.

There is constant formation of new **sacs** and **papillæ,** and of material for the shaft from the bottom, so that the hair is pushed forward, and its ends drop off after reaching their length. The shaft consists of a central pith, or **medullary** substance, which sometimes contains air, and of a **cortical** substance and an outer cuticle. The outside epidermic cells form a **root-sheath** around the root of the hair, which when it is pulled generally comes away with it. The hairs scattered over the skin evidently have slight movement under contraction of the **corium,** and with their oil-glands and their minute orifices help the functions of the skin. A good head of hair numbers over 100,000 hairs. The number, scattered all over the body near these minute gland-openings, amount to many thousands.

19. **Nails** have a similar development. A bed of elongated papillæ is formed, covered with growing epidermic cells in ridges which flatten and coalesce so as to form

the nail, and it is thrust forward by new growth, much after the manner of a hair.

It has been thus necessary to give with some detail the anatomy and physiology of the skin, because it is so complex, has so many offices connected with health, and is so external as to be far more subject to outer influences than some inner membranes. It is not only a covering, but a counterpart to all it covers, and a basis for adjustment between ourselves and the surrounding world. We have seen that, besides other variations in tissue, it has a wonderful network of circulatory vessels, of perspiratory and oil glands, and their ducts, with hair and nails formed of its own materials, besides pigment and other cells of various special type.

20. When we consider the uses of the skin in the animal economy we find that, (*a*) as an organ of excretion it ranks with the lungs and the kidneys; that, (*b*) as an organ of respiration it absorbs oxygen and yields carbonic acid, and has other interchanges that show it to be both excretive and absorptive. Upon it (*c*) more than upon any other part of the system we depend for the regulation of the temperature of the body, so essential to life and health. (*d*) It is an organ of sensation and touch.

21. Besides the protection it gives to the whole body as a covering, it has its own special provisions by means of (*e*) perspiratory and oil glands and hair-follicles and nails, and indicates to us its need of being unimpeded and often aided in its effort to rid the system from used-up material, to secure additional supplies, and to serve as a medium of exchange between that inner world (*microcosm*) which we call man and that outer world

(*macrocosm*), on his relation to which his welfare so much depends. It is, therefore, to be regarded not so much as a covering as an organ having complicated and essential relations to the whole system, — an outspread sheet of membrane, having offices similar to the more concealed sheets of folded vessels packed away under the name of lungs or kidney, and having in addition a collateral relation to the various and internal physiological processes of life.

22. It might be suggested that an organ showing such provision for cleanliness and for heat regulation might be depended upon to regulate itself, without any gratuitous offer of assistance from our own wills. But it is to be remembered that to a very great degree the adjustment of life to external conditions has been committed to ourselves. We have, in common with other animals, been endowed with instincts to a much greater degree than is generally recognized, by which we almost insensibly and as a matter of course make changes that are indicated. But as man is endowed with planning and thinking powers beyond the brute, he is also expected to find out by experience how to aid nature or how to adapt himself to changes.

23. It is also to be remembered that man, as we find him, is not in a natural state. He has been subjected to changes and influences which give types of heredity that affect not only individuals, but nations. Changes of climate, life in houses or in closely packed streets, subjection to various kinds of diet and embarrassments to health which arise from various mistakes or failures, or from the inroads of disease, are only to be met under that law of adaptability and adjustment which has so mercifully been put under the regulation of the individual.

From a study of all the facts to which physiology points, and which careful experience has certified, we are able to give very many rules that serve to aid us in management. While these rules are not absolute, they are very efficient as guides, and even the necessary deviations from them often become capable of determination.

24. **Care of the Skin, and its Functions.**—Surely we may state **cleanliness** as the first indication in respect to the skin. The very fact that it is a secreting organ, that it has sweat-glands and oil-glands, and that important changes are constantly going on in the blood as it passes from one set of vessels through minute capillaries or the walls of very thin membranes to another set of vessels, determine the fact that it must not be sealed up by any form of dirt or organic matter of any kind.

Experience is constantly attesting how much can be done in health and in disease by wise attention to the skin. We are familiar with the fact that these minute ducts, which open by millions on the skin, may become impeded by specks of retained matter, generally, but not always, too small for the naked eye to perceive.

We know, too, what wonderful effects can be produced upon the skin by the reaction following the use of water, and how the minute capillary vessels come to be better filled with blood, and have a more active circulation. The same is true of the **lymphatics**, which reach the skin, and which will be more fully described, in connection with the larger circulatory system.

No doubt the great means by which we relieve **congestion** of the internal organs, or their embarrassed functions, is through attention to the warmth and circulation of the skin. Its **nerve** condition, too, is much affected in the

same way. Even a mustard-plaster, by the redness it produces and the relief it often gives to internal pain, illustrates what can be done, either by direct or reflex nervous impression, to effect internal conditions.

25. The four principal methods, either alone or combined, by which we are to promote the health of the skin, and its adaptation to the needs of internal organs, are washing or bathing, soaping, oiling, and rubbing. Each, first of all, is valuable as a means of removal for all excretions from the skin, including not only the various secretions, but the minute scales of epidermis or scarf-skin which are so numerous, and which should be frequently rubbed off. All the four methods named give help in this direction. Often they are to be combined. It is one of the advantages of the bath, that it so often means, or should mean, the combination of all these to the degree that may be indicated, and that in the employment of these there may be derived many of all the benefits of general and recreatory exercise.

26. Even the ordinary washing, morning and night, means a very different thing to different persons. The man who stops at a stream, washes a little dirt from the hands, bathes the face a moment, and then rushes on, has used water, and may be refreshed by its coolness and wetness, but has not done much washing. From this up to a complete morning toilet there are more degrees of variation than some imagine. Should not the chief toilet be at night? A proper washing always includes a cleansing of the nails, a careful washing about the eyes and in the ears, a bathing of the neck, and such drying of the surface as amounts to a light friction of the skin. There is some reason to claim that these parts need more frequent

ablution than others, because more exposed to floating particles in the air. Next to these, the feet need most frequent cleansing. This arises from the fact that their frequent use causes more scarf-skin and secretion than most other parts. Being surrounded by a somewhat more impermeable covering than the rest of the body, the secretions do not find so ready diffusion. The nails, too, serve as points for the retention of effete material. It is not near as much the custom as it should be for persons to wash the feet daily. It need not be a foot-bath, but a simple wiping of the feet with a towel wet with cold or warm water, and a proper drying. There is no danger of taking cold from such a habit, but the feet are much more likely to be kept warm and to be fitted to endure cold or sudden changes.

27. The use of water all over the body, for the sake of cleanliness, varies with different persons. Some have a thicker skin, or are more abundant in their skin secretions, than others. While there is some force in the idea that those who perspire freely have more need for frequent washing, to remove the solid materials of the perspiration; yet it is also true that those of sedentary habits seem more likely to have stoppage of various ducts, and because of this need to have the skin more thoroughly washed and stimulated by friction. We have known persons so frequent and thorough in their ablution as to weaken and irritate the skin; but, as a rule, the error is in the other direction.

Most persons are benefited by a daily washing, or bath, and we have never known a person by nature so cleanly as not to be benefited at least by a weekly wash.

Gibbon says that for a long time Rome needed no

physician but the bath, and there is no doubt that the bath is a preventive as well as a remedial measure.

As chilliness and shivering are not desirable, there are many who do best to bathe in a room of a temperature of 65° or 70° F., and to whom water not too cool is best suited.

28. As to the temperature of the water, baths may be classified as follows: —

Cold bath, 60° F. to freezing-point.
Cool bath, 60° to 75° F.
Tepid bath, 85° to 92° F.
Warm bath, 92° to 98° F.
Hot bath, 98° to 112° F.

Blythe divides as follows: —

Cold bath, 33° to 75° F.
Temperate bath, 75° to 82° F.
Tepid bath, 82° to 90° F.
Warm bath, 90° to 98° F.
Hot bath, 98° to 112° F.

The usual internal heat of the body in health is quite uniformly maintained at 98.6°, whatever may be the coolness of the atmosphere at the outer surface of the skin.

29. The question has been raised whether complete submersion of the body under the water for several minutes, as in swimming, is not unnatural, as it deprives the body of its relation to the air, for which it is intended. There is reason to believe that such entire submersion should not be continued very long at a time. An able English physician has drawn attention to it as a cause of congestion of internal organs, and some diseases have been attributed thereto. In bathing for cleanliness, it is not necessary. The time spent in the water in sea-bathing is very apt to be longer than is best for health.

30. The benefits of bathing are much increased, both in promoting cleanliness and in softening the skin, by the use of soap, or some form of alkali. This use is based on the fact that the oil-glands of the skin may be deficient in action, or that small openings in it have become clogged or covered, or the scarf-skin has become by pressure or otherwise unusually adherent. As borax or soda will unite with the oily matter found in the skin, or will neutralize the acid of the sweat, and thus of themselves form a surface-soap, they are often used instead of, or alternately with, soap. It is often well to rub the entire body with a good quality of castile-soap, with only just enough water to make of it a lather, and so, for a few minutes before the washing, lubricate the body. In persons whose skin was sallow or lacked whiteness we have seen great benefit from this method of rubbing and softening the skin. The method now known as *Massage*, in which there is such a bathing, soaping, and kneading of the integument and muscles as to soften them, and increase flow of blood and nervous sensibility, has been found in many cases advantageous.

31. The **oiling** of the skin, so common among Oriental nations, is not so much needed in climates where clothing is used; but where there is apparant dryness of the skin. and feeble capillary circulation, it is of great advantage. The slight absorbent power of the skin is thus utilized. and it also tends to excite the glands of the skin into action. The amount of oil to be used is generally slight, and such kinds as have the least stearine are to be preferred. No doubt many of the liniments, which chiefly consist of some form of oil, cut or rendered more absorbable by alcohol or ammonia, are useful in this way.

When the skin has suffered in sickness, as in many fevers, and notably in scarlet-fever, the oiling has many advantages. The oiling should generally, within twenty-four hours, be followed by a tepid bath, or a washing of the surface with soft water, in which soda or borax is used in the proportions of a tablespoonful to a gallon of water, or else some form of soap which is a ready solvent.

32. In all use of **hard water** it is well to remember that its solvent properties are small. In fact, the continuous use of hard water often chaps the hands and face and roughens the skin. When the water is hard, it is better to use rain-water, or such as has been boiled.

The use of soap removes the temporary hardness of water, for by the mutual action of the soap and the compounds of lime and magnesia, the latter are converted into a lime (magnesia soap), and so a soft water is left by converting the mineral matter into an insoluble substance, or curd. Thus some soap is wasted, but the water is improved. Ordinary washing-soda softens water in the same way. So, also, on a large scale, as where water is needed to be softened for laundry purposes, a saturated solution of lime-water, or **milk of lime**, is made and added to the water. This unites chemically with the carbonate of lime in the water and precipitates it. As waters differ in hardness, the proportions needed somewhat differ. But, for ordinary hardness, one part of lime-water to about twelve parts of water will generally be sufficient.

In all matters relating to bathing and cleansing, the use of soft water is quite important.

33. **Friction** of the skin is valuable as a means of securing its healthy condition and that of the whole body.

We do not mean by this such hard rubbing as may be carried to the extent of irritation. But it is the general, gentle rubbing of the whole surface that is greatly conducive to health. The bare hands may be used for this purpose. Only those who have methodically practiced it know how the skin can be warmed and exhilarated in this way. It is the best remedy for cold feet or cold hands. A short time thus spent at the time of rising from bed, or before getting out of bed, or at evening upon retiring, aids much to quicken the capillary circulation, and to give a sensation of warmth. It is valuable for cleanliness, because it facilitates the removal of organic particles, and of the epidermis or scarf-skin. Sensitiveness of skin, and its power of sensation as an organ of touch, will be considered in connection with the organs of special sense.

34. In thus considering **cleanliness** we have, in fact, considered most that relates to our control over the skin as related to health; for one cannot thus treat it without promoting its secretion and excretion, its transpiration, its equability, or capacity to adjust temperature to our needs. The unimpeded circulation thus secured is the best guaranty against cold, and a great promoter of general good health.

CHAPTER VIII.

CLOTHING AND HABITATIONS AS OUR NEXT PROTECTION FOR HEALTH.

CLOTHING is important, not because it can originate or create warmth, but because it so utilizes the heat produced as to keep the air that is circulating about our bodies warm enough to make us comfortable.

So, in speaking of the skin, we associate with it the clothing. For many its only meaning seems to be that which has to do with decency, beauty, and taste. Important as all these are, the most important view to be taken of clothing is that which relates to the health. It is the **additional skin** which, because of changes of temperature and of conditions, often necessarily artificial, we are called upon to provide. Its design is to obstruct or regulate the abstraction of heat, which, as we learn from Physics, goes on from every warm or moist body placed in a cooler atmosphere, either by **radiation, evaporation,** or **conduction.**

2. The heat that is radiating from us is kept longer about us by our clothing; and even the thinnest clothing, such as a veil over the face, will lessen radiation, and so help to keep us warm. As about fifty per cent of air-heat is, under usual conditions, lost by radiation, we need to know how far clothing can interrupt this, and what kinds do it most effectually.[1]

[1] For definitions of *Radiation*, *Conduction*, and *Convection* see the chapter on HEATING and VENTILATION.

When we are surrounded by other bodies, or things equally as warm as ourselves, as in artifically heated rooms, or in a crowd with persons as warm as ourselves, our own radiation is exactly counterbalanced by that which is received from our surroundings, and our loss is chiefly by conduction and convection. This is chiefly accomplished by the currents of air moving about us. Fortunately, there is this constant movement of air, which is seldom less than one and one-half feet per second, and not perceptible as a draught until it amounts to about three feet per second.

3. Under usual conditions, the losses by **radiation** and **conduction** are the chief losses of bodily heat. When, however, these are insufficient, we fortunately have such a supply of sweat-glands and tubing in the skin, and such relations of the capillary circulation thereto, that the skin increases its insensible perspiration to sensible, and thus **evaporation** reduces the temperature and keeps it from becoming excessive. When the skin pours forth water, as in perspiring, the evaporation equalizes differences resulting from varying production of heat or from embarrassment of the other two methods. We have already seen how the miles of sweat-ducts can rapidly deliver this liquid. Its importance is seen from the fact that to change fifteen drops of water to vapor two and one-half caloric units are required.[1]

4. Between these three methods there is opportunity for delicate adjustment of heat. But even this, in changing climates and circumstances, depends much, in varia-

[1] A caloric unit is the heat required to raise the temperature of one pound avoirdupois of water one degree Fahrenheit.

tion and efficiency, upon the proper adaptation of clothing. Consequently, clothing has been very carefully studied. A common idea is that clothing is designed to shut out the air from our bodies, but as conduction and evaporation, and to some degree radiation, depend upon **air,** the complete shutting out of air would not conduce to healthy regulation of temperature.

5. The design of **clothing** is rather to catch between its fibers the circulating air, and so to regulate the temperature of the air between the outside and our skins as shall make it of comfortable warmth. Heat radiates from, and is conducted from or evaporated through, different forms and kinds of clothing at quite different rates. Color has an influence in relation to radiant heat received. In the presence of direct sunlight or flame Pettenkofer found for white textures the following proportions: —

When cotton received	100
Linen received	98
Flannel	102
Silk	108

With shirtings of different colors the proportions were:

White	100
Pale straw color	102
Dark yellow	140
Light green	155
Dark green	165
Turkish red	168
Light blue	198
Black	208

Hence, in this regard, the order of preference is generally stated thus: white, gray, yellow, pink, green, blue, and black.

In the shade these differences nearly disappear.

The power of absorbing odors is greatest in the following order: black, blue, red, green, yellow, white.

6. **Clothing** merely means to put materials between our skins and the outside air, which shall retard the outgoing of heat, and, meeting air, shall warm it before it reaches the skin.

One of the first facts which experiment has shown, and which is confirmed by experience, is, that it is not the substance and the weight, but the **texture** and the **volume**, that cause the chief difference. A loose substance, as in a new bed-quilt, greatly loses its power to help us retain warmth when it becomes compressed or packed. Hence, an article like feathers, which cannot be thus packed by use into a hard flat surface, is very valuable as a covering. The same is true of furs, and especially of the light hair near the skin. So three or four layers of the same article will keep us warmer than the same amount in weight closely compacted. A covering of fifty newspapers, for instance, one upon the other, will retain heat far more than if the same number are compressed into one mass. This is illustrated by the coldness of a very tight boot or glove in cold weather, as compared with one looser and of the same weight and material. Any garment for warmth must, therefore, admit of **air** next to the skin, and in its crevices or meshes. So garments made of very fine fiber are warmer in proportion to weight and thickness than those of coarser fiber. Persons who have tried the use of buckskin, or leather, or india-rubber, as a clothing, have found themselves suffering greatly when exposed to severe cold. These have their uses, but only as shutting out water, or cold winds, so far as is consistent with the free passage of air through garments beneath them.

7. "Our clothing not only renders the air still around us, but it also **regulates** its temperature by the heat which leaves our body; we heat our garments, and they continually heat the air passing through the meshes and pores of the texture. We may compare our clothing to a stove warmed by the heat emanating from our body-engine for the purpose of warming the air round our surface."

8. Another important consideration in the choice of clothing for health is that relating to its property of **condensing water** from the atmosphere, generally known as the hygroscopic property of different materials. This also, in part, determines the ability of various kinds of material to dispose of the perspiration from the body. A series of interesting experiments have been made as to this with the following results: wool has a greater hygroscopic power than linen; the maxima and minima of flannel being 175 and 75, and those of linen being 111 and 41. Linen is quickly wetted and soaked, wool more slowly, but linen cannot take up the same quantity. Evaporation is much quicker with linen. Drying proceeds much more evenly in wool. Linen, cotton, and silk become very quickly air-tight by wetting, but wool only after a long soaking.

9. The **elasticity of fiber,** on which the porosity of all fabrics chiefly depends, is very different in different materials. Here, again, wool stands apart; its fibers do not lose much elasticity when they get wet, while wet linen and silk lose it rapidly. The greater facility of catching cold in wet linen or silk than in wet wool is in exact proportion to the greater facility with which water expels the air contained in their fibers.

The more the **air** in any material is displaced by water the less it keeps us warm, the quicker it conducts the heat; hence, the frequent injury resulting from wet clothes, and the striking discomfort produced by a damp, cold air.

Cotton has many advantages over linen, but is not so universally applicable as wool. It conducts heat more rapidly than wool, and less rapidly than linen. It is very non-absorbent of water, and so cannot compare with wool in hygroscopic properties. Wool, for instance, has double the power of cotton or linen to absorb sweat. The **fiber** of cotton becomes **hard** or packed in wearing, and so diminishes in porosity. It has an advantage over wool in that it does not shrink in washing. Smallness of thread, smoothness of texture, and equality of spinning have much to do, not only with the quality, but with its hygienic value as clothing. When cotton of well-woven, smooth texture is mixed with wool, in the proportion of about fifty per cent **woven** in the same thread, it makes a valuable garment, which, without unduly diminishing the thermal and hygroscopic value of wool, prevents shrinkage, by which, in time, the wool fiber itself would become harder and less absorbent. All these articles for clothing may differ somewhat in their regulative power as to heat and moisture by difference in quality as well as in material or fineness of thread or texture. Thus, if the garments are made of old, or worked-up wool and cloth (known as shoddy), the fiber will have been compressed, and be quite different from that of fresh wool or cotton. **Smoothness** and **softness** and **closeness** of texture, with weight large in proportion to bulk, are the general requirements for suitable clothing.

10. Coverings for Different Parts of the Body.— Head-covering. The essentials for a good head-covering, as to **quality** and as to **material**, are the same as for other parts of the body, with a few slight modifications. It should be remembered that the natural hair of the head is a protection against alternations of heat and cold. Where there is thinness of hair, or baldness, special attention must be given to the protection of the head from draughts or from severe cold or heat.

The head-covering in general should be as **light** as is consistent with durability, and should not press too closely the head or the hair. So the band of it about the head should not be tight; and, to secure movement of air inside, the cap should usually have small perforations in the top. Parkes thus describes the Glengary Scotch-cap, which he commends: "It is very soft and comfortable, presses nowhere on the head, has sufficient height above the hair, can be ventilated by openings when desired, cannot be easily blown off, can be carried at the top of the head when desired in hot weather, or pulled down completely over the forehead and ears in cold weather." How easily the temperature of the air inside of a cap may be affected was shown when, in India, white cotton covers were ordered for caps in summer, and it reduced the temperature of air in the cap about 4° to 7° Fahr. In very hot weather a wet handkerchief in the top of the hat, if it has good ventilation, acts as a cooler. In all close head-dresses, too, little attention is given to the heat of the inside air. Women, with all their varieties of head-costume, as a rule, have more healthy head-coverings than men. Ornament is not to be objected to, if protection and lightness are regarded. The addition of large

masses of hair is of course objectionable, if, either by thickness of covering or weight, it surpasses the ordinary provisions of nature.

Baldness is often hereditary, and results either from some condition of ill-health which has caused the falling off of the hair, and not infrequently from neglect of the scalp or too much cap-covering.

11. **Protection of Face and Neck.**—The face and the neck are generally safe to be left uncovered, except in excessive heat or cold. It may be claimed that slight protection of the upper part of the neck is required for those exposed to vicissitudes of weather. For this purpose the beard seems to have been given to man. The protection should not be such as to press upon vessels or impede the natural movement of the neck. In cold winds, the space about the neck may afford too free entrance for wind over the chest, and so it is wise to have a small silk or woolen handkerchief to place temporarily around it. But for general use, there is much to be said against neckcloths which are wrapped about the neck.

12. The **covering** of the rest of the body in a climate subject to many changes, in which, by means of transportation, we are rapidly exposed to great changes of the latitude and longitude, becomes a most important consideration. Besides usual clothing, overcoats, shawls, and blankets, for adjusting ourselves to changes, are very valuable.

It is well agreed, both from experiment and experience, that woolen, or woolen and cotton, so mixed as not unduly to decrease the porosity or obstruct the air, and to combine lightness and non-contractility, are de-

sirable. We must learn to adjust the undersuit to our needs, and not hesitate to make frequent changes, if variations of exposure require it.

No part of the body below the neck should be without protection, in summer and winter. In the winter, it is a question of warmth; in summer, it is to have an absorbent for the perspiration, and to protect from the changes which are common between noon and midnight. Often the thinnest and finest forms of merino are best in summer, and are not to be dispensed with. Compensation can be had by having the more exterior garments light or thick, as may be needed. Those who are susceptible to change get much advantage from a double undersuit, the inner garments being much the thinner and finer. The socks are better if made partly of wool. A thinner inside sock is often worn with benefit.

13. Great advantage for **cleanliness and health** is obtained by having both a night and day undersuit, so that one can be refreshed while the other is worn. Soldiers or others not well provided or situated for other changes find a double suit, thus used, much better than the continued use of the same suit in succession. In India, the English soldiers often wear a double fold of flannel around the abdomen, which is called a cholera-belt. In washing clothing containing much wool, it should be put in hot soap-suds, and rinsed in cold water, without much rubbing, and dried without wringing.

14. As the question of excessive or defective covering is a relative one, it is much better to announce principles than to designate precise weight or amount. The usual weight of clothing for a soldier, without overcoat or boots, is stated at ten pounds.

Not much need be said of **linen** or **muslin** as the next covering. These are not objectionable, unless so thickly starched as to be too impervious or too rough. They give slight additional protection. We have already noted these in comparison with wool and with cotton of different texture.

Having protected the skin with inner garments, chosen on the principles here discussed, it matters comparatively little what form the other coverings have, except that they are to be made of materials which will be an additional protection, and so arranged as not to give an unequal temperature. Thus there is no good hygienic reason for the covering of the body with pantaloons, vest, and coat, and then, as in a dress-suit, leaving the whole front with an open breast. Yet if it must be done, let some under garment make up for the opening.

15. Of all these coverings, the **waistcoat** is the most important. If made of wool, or of mixed wool and cotton, if as thick on the back as at the front, and if closing in front to a point where it is joined by a woolen or silk scarf of about the same capacity for retaining heat, we have the article of dress next in importance to the undersuit. It incloses the organs which in their relation to the atmosphere are more vital than any others. All females should have a corresponding covering in some form which will not prevent any outside form of appearance or adornment which may be desired. Let dress and taste have their sway, if only the body, more precious than either, has proper protection.

16. All other forms of clothing, except those to which we have alluded, are to be such additions as will not interfere with **action** or **protection**. Coats, overcoats, dresses,

are all to be studied with the same general view. The chief danger as to these is from the undue amount, or the mode of adjustment. While the **shoulders** and the **hips** are both adapted for the bearing of some additional weight, it should be not so great as to be burdensome, and not such as unduly to impede motion. A narrow and slipping suspender or arm-loop is quite different from one of moderate elasticity, so joined with its opposite, if need be, upon the back as to afford an easy upholding. A series of small cords about the waist, and a weight of several unnecessary pounds, may be a great embarrassment as a load, or as respects motion. The shoulders and the hips should each bear a part. Dress can be so made that the support is divided. There are many reasons why the female dress should receive the careful consideration of those who are not easily led to advocate grotesque costumes, but who really believe that when a hygienic demand is made apparent, dress and taste will succeed in conforming itself thereto.

The principles of physical science and art, which are so much at the basis of all practical hygiene, are teaching us how it is possible to **distribute** the weight of the lower garments, to make them flexible, yet firm enough not to embarrass locomotion, and with the addition of the close and indispensable under-garments to give a protection consistent both with health and taste. No one who desires vigor can afford to overlook the principles which underlie dress as a comfort and health as well as beauty. Much evil has undoubtedly arisen from an undue pressure of dress over the chest and abdomen.

17. The use of **bands** to fasten sleeves or stockings is also recognized as doing much harm, unless they are

more elastic and less close fitting than many bands having the name of elastics. It is deplorable to find how often varicose veins and ulcers and enfeebled or diseased limbs have resulted from this cause. Those of the manual labor vocations especially suffer from various forms of bands and bandages used to keep garments on or in their places. Where varicose veins have been produced, early attention should be given to securing elastic stockings or other means of artificial pressure.

18. The protection of the feet is especially indicated because they are apt to become cold whenever there is much languor of circulation, and to become cold or wet by exposure. We have already alluded to the fact that not enough care is taken of **the foot**, so as, by washing, oiling, rubbing, and properly fitting coverings to it, to give it the advantage of a uniform healthful condition. After the clothing which we give to it, in common with the rest of the body, we add **leather**, because, if well prepared, it is soft and porous, and it also has some firmness for impact, and retains heat. In very windy climates, coats are made of it, and it is much used as temporary outside coverings. In the coldest nights, the Anatolian shepherds lie out in their sheepskin coat and hood without injury, though unprotected men are frozen to death. Judged by the standard of hygienic clothing, it must be claimed that many thicknesses of leather are not desirable. Neither should a leather, covered with an impermeable coating, be worn continuously, however desirable it may be, for a time, to keep the feet from getting wet. It is but little better to wet the feet by retained perspiration, or interrupted evaporation, than

by exposure to outside moisture; a very impermeable leather is therefore objectionable. As boots and shoes, if old and long worn, are soiled by the organic particles from the feet, inside disinfection and drying are often desirable.

19. **Waterproof Clothing.** — This principle as to the use of leather applies to all waterproof clothing. Because it protects from rain and wind it is often valuable for use amid exposure. But because of its interference with temperature, and especially as causing condensation and retention of perspiration, it is not a good permanent clothing. The effect is somewhat modified when the waterproof has a woolen lining. For **temporary use** this kind of clothing is valuable. The same applies to the use of **rubbers** for the feet. When india-rubber boots are worn a day or more at a time, it is best to have soft woolen or chamois sandals to wear within them. Individuals differ much as to their readiness of perspiration, and especially as to that of the feet. Where rubbers are found to produce moisture of the socks and feet, they had better be avoided, except during actual storms. Much depends as to the use of waterproof clothing on the condition of atmosphere. In cold storms it can be worn much longer and more safely than when the weather is warm and the air highly charged with moisture.

20. Thus it is seen that the whole subject of clothing has very important hygienic relations, — such as have their basis in the ascertained facts as to the character, make, and color of fabrics, and as to the physiology of life. It is a matter in which there must be **compensation** and **adjustment** to the varying conditions of ourselves and

the atmosphere about us. But these facts aid much in guiding us. **Gloves** and coverings for the wrist need only the same principles to guide as those for other exposed parts. In very cold weather we economize heat by closing all apertures for its escape. So if the dress about the wrists or feet is closed, there is less access for currents of air and less egress of heat.

21. It is to be remembered that about **one-third of life is spent in bed,** and our clothing, while in it, is a matter of great importance. The same principles presented as to day-clothing apply here, except that there is no need of such as protects from wind and rain. The linen or muslin sheet is not objectionable if it has above or beneath it the woolen blanket. Feathers and hair-beds are good, if the material is always nicely kept. If not, the dependence should be more upon spring-beds and blankets. It is well to bear in mind that when in bed in a horizontal position the constant flow of air around our bodies causes the strongest currents to be ascending toward the head. So, if the air is impure by reason of any want of care or of change of under-garments, the lungs receive more than their share of organic matter. Cleanliness and warmth of clothing without undue weight, and such extra clothing as can be put on or laid off at pleasure, are very important for the bedroom. **Heated bed-rooms** are seldom needed for the young, and there should always be some arrangement by which fresh air can be admitted without draught. **Foul air** always makes demand for more clothing.

22. **Habitations.**—Our next artificial method of adding to the covering afforded by the skin and by clothing is that of a habitation or dwelling-house. It is an effort

to adjust ourselves to the world about us by providing another external means of covering. It is only an addition to clothing, so that where it suffices no house-covering is sought. Where more is needed, the provision ranges through all degrees, from that of the occasional shelter against wind or rain or sunshine to that against cold.

23. As with clothing, so with houses; those are the best which give us the outside air, delivered from those extremes which are found uncomfortable or unbearable. Thus, if we could be put in houses whose walls no air could penetrate, we would be much in the same plight as if our skins were covered with varnish, or our constant garments were all water and air proof. It is because bricks are porous to air that they are so much used in building. If the bricks are soaked through with water, there is no room for air in the spaces. Then they become air-tight, and by reason of dampness and lack of air we could not live in such a house.

The questions, then, as to a good house are: How shall we build it so as to secure **purity of air** in it? how shall we adapt it for proper coolness when it is too hot out of doors, and for proper heat when it is too cold without?

24. Our first attention must be to the ground upon which it is built. It must be so porous by nature or so kept by art that air may permeate that part of it on which the house rests. If there is undue water it will not only abstract heat, but it will be drawn into the building material and help to shut out pure air of proper temperature. Therefore the person seeking this **additional clothing** needs a **dry soil**, and for a reason similar to that for which he needs a dry garment. Hence underdrain-

ing and cement floors and sides, and sometimes a damp course of slate or asphalt, after the foundation is above the ground, are necessary in order to protect the building material from sucking up water instead of taking in air. A drainage toward the house, loose soil about the building, the discharge of roof-leaders on the ground, and the shutting out of sunlight, are among the causes which often add to the dampness of the ground, and render houses damp and unhealthy. It is because painted and papered walls serve to prevent the circulation of air from without and within, through the bricks, that they are not as healthy as walls of different finish. But where the ground and walls are very dry, there will still be circulation, and the evil is trivial. Not so, however, where there is great dampness, or where new paper is put on without removing the old.

25. From what has been already said, we know that clothing that becomes full of dust or dirt, or sealed up by being greasy, is not fit for use, because the air is thus in part excluded, and what there is is laden with particles and gases that hasten to decomposition.

For just the same reasons, the house that is full of dust or decaying matter in the walls, or in the air of the rooms, also needs to be washed and aired. The reasons for clean houses and thorough housekeeping are the same as the reasons for clean clothes and a clean skin. The care of dwellings, school-rooms, and all houses, therefore, requires all the details of the most thorough airing and cleansing, and all facilities for securing them.

26. As by virtue of the necessities of civilized and domestic life, there are **produced in the house** many sources of foul air, we are to be constantly on the alert to

remove these or to compensate therefor. We thus study to have the dwelling permeated by pure air, so tempered in its velocity of movement as not to occasion undue draught, of such temperature as not to chill, and of such quantity as will dilute the air which is constantly being deteriorated; also there is need to provide means for letting out the air of the room so that constant entrance, dilution, and displacement may go on.

27. As to school-houses, and all public assembly-rooms, we are to remember that in these we have even greater demands for purity of air; and yet by reason of numbers, and various other circumstances, it is more difficult to obtain the needed supply. How this is to be done we shall have occasion more fully to discuss when speaking of VENTILATION and HEATING. At present, we only have occasion to note the house as a form of clothing, and as aiding the body and its covering, the skin, in the adjustment of the world without to the world within.

CHAPTER IX.

THE BLOOD AND ITS CIRCULATION.

AS the chief function of the lungs is to affect the blood, we next come to inquire as to it, and the force and mode of its circulation. The minute capillaries (Lat. *capillus, a hair*), or blood-paths, with which we have had to deal in the lungs are but the terminal fibrillæ of an immense system, having its origin at a central organ. These minute tubes enlarge into others known as **arteries** and **veins**, the one class of vessels carrying blood from the heart and the other class distributing it thereto. As we shall hereafter see, when speaking of FOODS, these vessels are the carriers of blood, and of the blood material which is gathered from the digestive canal after it has been duly prepared. The mode by which it is gathered and enters the circulation we shall see in our study of the digestive apparatus.

2. The shape and position of **the heart** are best illustrated by presenting it as located in relation to the lungs. See diagram, p. 156.

A section of it, on the next page, as seen from the front, will give some idea of its inner structure. It is located in the central part of the thorax, or cavity under the lower two-thirds of the sternum, or breast-bone. Its apex or lower end extends out beyond the breast-bone between the left fifth and sixth ribs, and can be felt by its beat about two and one-half inches to the left of the median

line. In a full-grown man it is about five inches long, three and one-half inches broad, and two and one-half inches thick, and weighs about ten ounces. It is a rounded conical organ, the shape of which can be filled

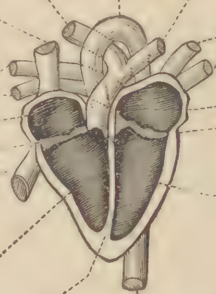


FIG. XVII. — Section of the Human Heart. Frontal aspect.

out from the diagram. It is divided by muscular walls into four cavities, the two upper ones being called **auricles** and the two lower **ventricles.** It is more significantly spoken of as the right and the left heart.

3. The **right auricle** receives into it the blood which flows to it from the great veins, and by its contraction passes it on into the right ventricle. The **ventricle** in contracting forces the blood through the large vessels called the pulmonary arteries. This right heart is, therefore, sometimes called the **pulmonic heart.** The dark or venous blood which has been gathered from the whole system is forced by the right heart into the lungs; it is then spread out over a vast network of capillaries, or small blood-vessels, as before noted, through the thin

walls of which it comes in contact with the inbreathed atmospheric air. Thus it parts with those portions of its contents which are no longer of use, and, receiving **oxygen** from the air, is converted into red or arterial blood.

4. This blood passes from the lungs by its pulmonary vessels to the **left auricle** of the heart. This contracts and sends it into the **left ventricle.** This is a cavity with strong muscles and great propelling power, and throws the blood with great force through the **semi-lunar** valves into the large tube known as the aorta. From it, through the branching vessels, it is distributed to the whole system. The impulse it thus receives is conveyed to all the arteries, and is called their pulsation. We generally feel for it at the wrist, and call it the **pulse.** The preceding diagram sufficiently marks the general location of the various parts of the heart.

5. The right auricle of the heart is separated from the right ventricle by a valve known as the tricuspid valve. The left auricle is separated from the left ventricle by a valve known as the mitral valve. The ventricles are a little larger than the auricles, and each is capable of containing from four to five ounces of blood.

It is thus seen that the human system contains a perfect apparatus for the distribution of the blood to every bone, muscle, and fiber of the system, as also a method for securing its purification. The fluid itself may be said to have two bases of supply, together with associate or intermediate provisions for the removal of all foreign or used-up or deleterious materials.

6. The food, through the alimentary canal, gives the **primary** supply, while the same canal, which imparts the

food, has collateral to it various separaters which remove and discharge extraneous material. So also the heart has its way of sending the blood up to the lungs, that it may there be rid of materials no longer wanted, and also receive a supply of life-giving oxygen to do its work in the various changes which it secures throughout the system. The amount of blood on an average is calculated to be about one-thirteenth of the weight of the body, so that in a person weighing one hundred and thirty pounds it would be ten pounds.

7. We now come naturally to inquire what blood is, and how, as thus distributed, it imparts life and vigor to the human system. As we look at it, it seems to be merely a reddish fluid, varying from red to **dark blue,** accordingly as it has come from arteries or capillaries or veins. If, however, some is drawn, it soon becomes jelly-like. After a little, a clear yellowish watery-looking fluid appears on the surface and about the edge of the vessel, while the central part is a red semi-solid mass. The liquid we call the *serum* of the blood, and the more solid mass the *clot.* As we come to examine the *clot*, we find it made up of various minute *corpuscles*, or minute rounded or oval bodies, and that they are held together by *fibrin*, a substance with which we will come to be familiar in the study of foods. The *fibrin*, too, we find to have originally belonged with the *serum*, and with it to have made what is known as the liquor **sanguinis,** or **plasma.**

8. When the **corpuscles** come to be studied they are found to be of two varieties, known as the red corpuscles and the colorless or whites corpuscles.

The former are much the more numerous, while the latter are somewhat the larger.

The red corpuscles are flattened, circular discs averaging $\frac{1}{3200}$ of an inch in diameter. The colorless corpuscles average $\frac{1}{2500}$ of an inch in diameter. They form what is called a nucleated cell, from which it is quite certain that in some way the red corpuscles are derived.

9. Considered chemically, the blood is an alkaline fluid, consisting of water, of solid and gaseous matters. "The proportions of these several constituents vary according to age, sex, and condition, but the following statement holds good on the average:

"In every 100 parts of the blood there are 79 parts of water and 21 parts of dry solids; in other words, the water and the solids of the blood stand to one another in about the same proportion as the nitrogen and the oxygen of the air. Roughly speaking, one-quarter of the blood is dry, solid matter; three-quarters water. Of the 21 parts of dry solids, 12 (equal four-sevenths) belong to the corpuscles. The remaining 9, or about two-thirds (equal to two-sevenths, or the whole solid matter), is albumen, a substance like white of egg, coagulating by heat, and one-third (equal one-seventh of the whole solid matter) a mixture of saline, fatty, saccharine matters, sundry products of the waste of the body, and fibrin.

10. "The total quantity of gaseous matter contained in blood is equal to rather less than half the volume of the blood; that is to say, 100 cubic inches of blood will contain rather less than 50 cubic inches of gases. These gaseous matters are carbonic acid, oxygen, and nitrogen; or, in other words, the same gases as those which exist in the atmosphere, but in totally different

proportions; for whereas air contains nearly three-fourths nitrogen, one-fourth oxygen, and a mere trace of carbonic acid, the average composition of the blood gases is nearly two-thirds carbonic acid, rather less than one-third oxygen, and one-tenth nitrogen.

11. "It is important to observe that blood contains much more oxygen gas than could be held in solution by pure water at the same temperature and pressure. This power of holding oxygen appears in some way to depend upon the corpuscles, firstly, because mere serum has greater power of absorbing oxygen than the pure water has; and, secondly, because red corpuscles suspended in water, instead of serum, absorb oxygen very readily. The oxygen thus held by the red corpuscles is readily given up by them for purposes of oxidation, and indeed can be removed from them by means of a mercurial gas-pump. It would appear that the connection between the oxygen and the red corpuscles is of a peculiar nature, being a sort of loose chemical combination with one of their constituents, that constituent being the hæmoglobin; for solutions of hæmoglobin behave towards oxygen exactly as blood does.

12. "The corpuscles differ chemically from the plasma, in containing a large proportion of the fats and phosphates, all the iron and almost all the potash of the blood; while the plasma, on the other hand, contains by far the greater part of the chlorine and the soda.

"The blood of adults contains a larger proportion of solid constituents than that of children, and that of men more than that of women; but the difference of sex is hardly at all exhibited by persons of flabby, or what is called lymphatic, constitution.

13. "The total quantity of blood contained in the body varies at different times, and the precise ascertainment of its amount is very difficult. It may probably be estimated, on the average, at not less than one-thirteenth of the weight of the body.

"The function of the blood is to supply nourishment, too, and take away waste matters from all parts of the body. It is absolutely essential to the life of every part of the body that it should be in such relation with a current of blood, that matters can pass freely from the blood to it, and from it to the blood, by transudation through the walls of the vessels in which the blood is contained."

The circulation of the blood is affected or embarrassed in various ways.

Persons subject to fright or frequent excitement are likely eventually to have some trouble of the heart or the larger blood-vessels. It is true that the heart is made to endure many variations, but **frequent** and **rapid changes** of heart-beat are to be avoided.

14. The effects of **stimulants** upon the circulation need careful consideration. In the study of Drinks and Condiments we will have occasion to notice their dietetic effects as allied with their effects on the circulation. There is no effect of **alcohol** more insidious than that produced by the **nervous thrill** it imparts to the action of the heart, and which is propagated all along the various vessels of the circulation. Even the temporary benefit derived from it, in cases of collapse, is most forcible evidence that its frequent or continued use is attended with most disturbing results.

The minute **enlarged capillaries** often seen upon the

face, and the general redness of countenance produced by alcohol, in many who are regarded as temperate in its use, are the forcible declaration, that to the very tip-ends of the circulating system it is capable of **suspending contractile action**, of **paralyzing vaso-motor** nerves, of **weakening** the caliber of the vessels, and of producing permanent **engorgement** or **congestion** in them. If this is true of the minute vessels of the face, it is equally true of those of the lungs, the liver, the kidneys, and other organs. When it is remembered that most of the vital organs are made up of millions of these little arterioles and veins, what takes place on the skin is the demonstration of far-reaching and abiding **impairment** of all vascular organs.

15. In different persons different organs seem to feel the severity of the disturbance, but all are more or less weakened. Authorities may differ in their estimate of causes which have produced embarrassing and finally fatal changes in various secreting and excreting organs, but we believe no one has yet been found to dispute the **unrivalled capacity of alcohol** to produce **irritative** and **degenerative changes** in the minute **capillary circulation** on which the integrity and ability of the vital organs depend. This does not absolutely retire it from use in the hands of the skilled physician in emergencies of disease, any more than it does opium, belladonna, or corrosive sublimate, but it does certify that alcohol is the most **riskful** of **drinks,** in all that relates to the circulation of the blood in those organs whose **vitality** and **function** depends on the perfectness of their capillary circulation. It is essentially a disturber of the rhythm and the function of the blood-flow.

16. The **blood** is found to contain all the material needed for the nourishment of the entire system, as derived from ordinary food. Intermediate between it and the food we have a fluid that is known as lymph. This is contained in the **lymphatic vessels.** These are the vessels which absorb chyle from the digestive track. This, mingling with the juice peculiar to the lymphatics, is conveyed into the thoracic duct, and so into the blood current. The lymph-vessels have, in their course, small solid, oval, glandular bodies, varying in size from a millet-seed to an almond, through which they pass on their way to the thoracic duct. The chief of these are found in the neck, the axilla, the groin, and the mesentery, and are called glands.

All parts of the body which have capillaries, except perhaps the bones, brain, and spinal cord, eyeballs, cartilages, and tendons, have also these lymphatic vessels intermingling with the blood-carrying vessels, though not in direct communication. They are not supplied by any large vessels bringing food to them, but open into vessels or trunks which carry fluid from them. These various trunks center into and ramify through the lymphatic glands. Finally, most of these lymphatic tubes, after thus twisting about amid glands, pour their liquid into the **thoracic duct,** which runs up along the spinal column and empties its contents into the blood circulation at the junction of the left jugular and sub-clavian veins. The lymph is blood minus its red corpuscles, and becomes changed as it mingles with the current.

17. The **spleen,** a small spongy organ to the left of the stomach, is regarded as having important relations to the blood and the lymph circulation, but these are not

as yet so known as to bring it within the reach of hygienic care.

18. The blood is being constantly added to by the life-supporting constituents it is constantly deriving from foods as well as from the air, while it is also the receiver of material from all parts of the system. It has been compared to a **river,** the nature of the contents of which is largely determined by the nature of the head-waters and of the animals which swim in it; but which is also very much affected by the soil over which it flows, by the water-weeds which cover its banks, and by affluents from distant regions; by irrigation-works which are supplied from it, by drain-pipes which flow into it. Even the change from venous to arterial blood does not take place in the lungs only, but in most parts of the body, the skin especially being the analogue of the lungs.

There is a real difference in the quality of blood, as the body is well or illy nourished, as well as from the infusion into it of deleterious substances. By comparing the composition of foods, of the blood and of the various tissues, we are able to arrive at quite definite conclusions as to the demands of the human system.

19. From what we have seen of the course of the blood and of its uses, it is evident that we should not, by undue **pressure,** interfere with its natural flow. **Exercise** strongly determines its **activity** of flow. We are so constituted that, if we live indolent lives, or if the skin is so obstructed as to interfere with its natural action, the same amount of blood will not find its way into the minute vessels which form the boundary between ourselves and the world about us. As the drawing of blood to the surface relieves internal congestion, so

those who do not properly use the limbs and muscles have the blood too much centered in or about the internal organs.

20. The **hygiene** of the **blood** requires proper food, exercise, cleanliness, right living, and sound organs, and then the system will not fail to make use of its natural powers of construction, elimination, and repair. The importance of a natural distribution of blood is seen when, by some sudden shock of the system or failure of heart-action, faintness is produced. The heart becomes disturbed in its action, and the person turns pale, and will fall unless there is speedy relief. When a person suddenly turns pale or faints, he should be at once put in a reclining posture at full length. Pure, fresh air should be secured, and water sprinkled in the face. A drink of water, or the smell of vinegar, ammonia, or other strong scent, will often aid in recovery. All these are useful, because they aid to restore the proper circulation by a quick impression made on the nervous system, and transmitted to the blood-vessels. Clothing, if tight, should be loosened, and especially about the waist and neck, to remove all pressure from the blood-vessels.

21. Faintness illustrates how the circulation of the blood is connected with the nervous system. Minute nerves, known as the nerves of the vaso-motor system, supply all the blood-vessels, and the tubes are more or less responsive to nervous impressions made upon the senses. Thus, a man once reaching up to hang a piece of meat caught his arm violently on the hook and fainted, but when the coat was taken off it was found that the flesh had not been wounded. We find, too,

how even the nervous and circulatory system can be educated. The person who tries to resist faintness is not so apt to faint. Many a person who at first faints at the sight of blood becomes so accustomed to it as not to be affected by it.

22. **Nose-bleed** generally denotes either thinness of blood or a tendency of too much blood to a particular part. It sometimes results from the wounding of some small vessel by pricking, or from an irritation of the nose in some way. When from one nostril, it is often easily stopped by closing that nostril with the ball of the thumb and inbreathing with force through the other. Cold applied to the head and neck, or the snuffing of a little alum or alum-water up the nose, is often efficacious. When there is bleeding from a **wound**, bring the sides of the wound closely together, and then wrap it tightly about with a bandage until a physician comes.

23. If an artery is wounded, tie a handkerchief tightly **above** the wound, and twist it about with a lead-pencil, or larger stick, until the surgeon arrives. We have known all sorts of things, from salves and starches down to spirits and tobacco, put into wounds to stop bleeding, or to heal them; but beyond a little oil, to keep the bandage from sticking, just over the cut, such applications are not necessary. Often scars or sores come from the neglect of cuts, which if neatly joined would heal as it is called by first intention. When there is hemorrhage from the throat or lungs, perfect rest, pure air, and a mustard-plaster to the chest, and the use of ice or a strong solution of salt, or a few drops of turpentine on sugar, are the best measures until further aid can be had.

CHAPTER X.

THE LUNGS, AND THEIR RELATION TO HEALTH.

NEXT to the skin, in its contact with the outside world, we come to consider the **lungs** and their office work as related to the maintenance of health. We are so constituted that the blood, which is the vehicle of life, in its circulation through the system must be spread out, as it were, in sheets over surfaces against which air is let in, so that it may receive oxygen from the air, and give up carbonic acid, gases, and particles of organic matter, which the system must get rid of by such means. As **air** with its **oxygen** is the only mixture of gases fitted for this purpose, it must have free access to the organs in which the chief apparatus for aerating the blood is located. This consists of two organs known as the lungs. They are situated within the ribs on each side of the median line of the body. They are formed so as to present, in the smallest space, a very extensive surface of blood to a very large surface of air. A sheet of air is thus spread alongside of a sheet of blood with a membrane between, so thin that oxygen, carbonic acid, and other ingredients, interchange freely.

2. The **lungs** are two large, spongy, elastic organs occupying the right and left sides of the thorax, or chest. The chest includes the back as far down as the lower ribs. They consist of lobes which are divided into

lobules, or small sacs, each of which is a little lung of itself. Under the stimulus of air and blood, these air lobules, or vesicles, expand and contract, and do their work of interchange. The right lung is a little larger than the left, and has three lobes, while the left

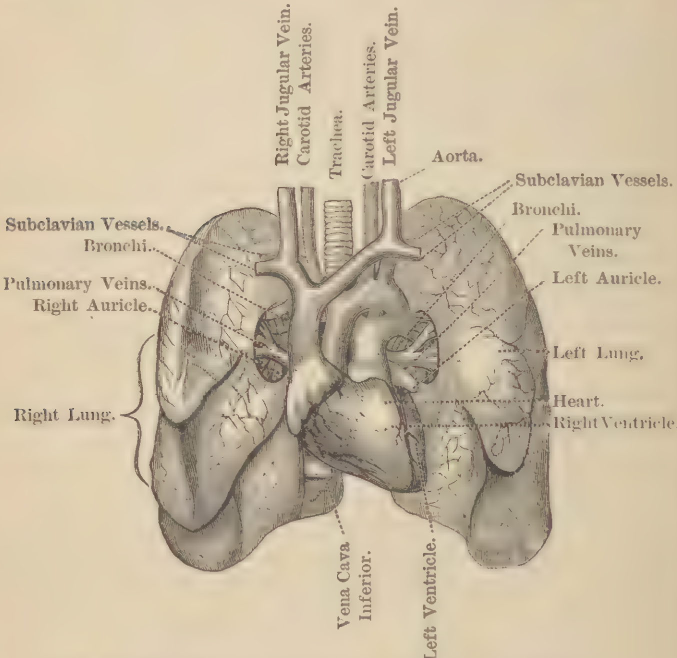


FIG. XVIII.—The Heart, Large Vessels, and Lungs.

has but two. The two lungs weigh about twenty-four ounces. Their relative position is shown by the figure. When healthy, the lung is so light, and has so much air in it, that it floats in water, and is the only one of the viscera that does. These two air-sponges, although

contained in so small a space, have a very large capacity. Over one thousand gallons of air pass through them each day, and in active exercise they may be made to use two thousand gallons per day. To distribute the air to these air lobules a system of tubes is necessary.

3. The system begins with the **trachea** (Gr. *τραχύς*, *rough*), or **windpipe**. This is a membranous tube, kept constantly open by from sixteen to twenty cartilages which extend around about two-thirds of its circumfer-

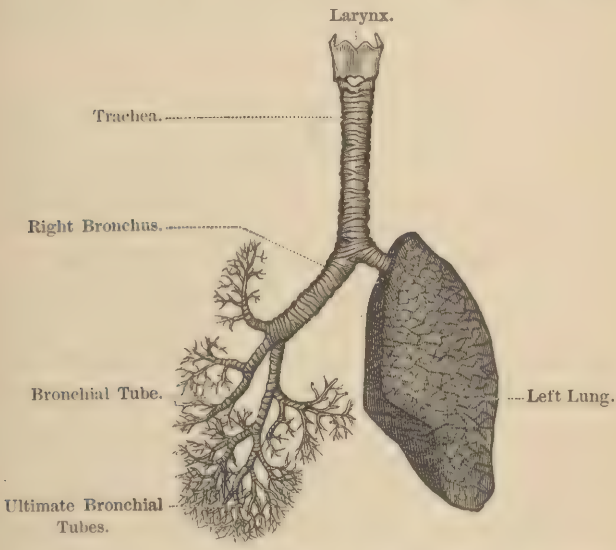


FIG. XIX.—Air Tubes of Right Lung exposed, and Left Lung.

ence. It is about four and one-half inches long, and three-fourths of an inch in diameter. Beginning at the **larynx**, or voice-box, it extends down to opposite the

third dorsal vertebræ, where it divides into two branches, which, in their turn, divide into multitudes of bronchial tubes.

This system of tubes is known as the **bronchi** or bronchial portion of the lungs. The subdivision is well shown in the preceding plate. Bronchitis is inflammation of these tubes. The ultimate or smallest bronchial tubes terminate in **infundibula,** or air-sacs, which are minute conical expansions of the ultimate tubes about $\frac{1}{40}$ of an inch in diameter. Their walls are, as it were, puffed out like tucks or minute pouches or saccules, and are called **air-cells.** Their number is not less than 600,000,000.

4. These air-cells are about $\frac{1}{200}$ of an inch in diameter. Between these vesicles are intercellular passages, in which a delicate yellow, elastic tissue gives support, and a rubber-like readiness of motion. The respiratory surface afforded in the two lungs is not less than 1400 square feet. On the outside, and just alongside of all these vesicles of air, is a capillary network of minute blood-vessels, almost countless in numbers, and varying from $\frac{1}{3000}$ of an inch in diameter to smaller sizes. The **heart and circulation,** as controlled by the nervous energy, causes the fountain of blood from the entire system to be distributed in these, and so to come alongside of the fresh, pure air, and make that interchange on which life depends. **Breathing** is the process by which pure air is drawn from the outer world into the trachea or windpipe through the nose and mouth. Entering these minute air-cells it gives up its oxygen to the capillary circulation, and receives in its stead carbonic acid gas, watery vapor, and all gases or decayable organic matter that can thus escape by expiration.

5. The heat of the **expired air** is about 98°. About 360 cubic feet of air is thus passed into the lungs, in ordinary quiet life, in the course of each 24 hours. About 10,000 grains, or 18 cubic feet, of oxygen is thus given up, and about 12,000 grains, or over 21 cubic feet, of carbonic acid removed. With it is given off about 9 ounces of watery vapor, and a varying amount of epithelial cells and other highly decomposable animal matter. All of the air vesicles of the lungs are not used at each inspiration or expiration, but there is a reserve for such times of exertion as require the inhalation of a larger amount of air.

6. But even where there is rapid expiration, considerable air is left in the lungs. That which passes in and out in ordinary breathing is sometimes called the **tidal** air. After an ordinary inspiration, there is about 200 cubic inches of air in the lungs. Only from 20 to 30 cubic inches passes in or out at each breathing. As this residual air is always present, it forms an atmosphere in the lung, into which the carbonic acid and other used-up materials are infused, as also the pure air which is inhaled. It thus becomes the **medium of exchange** between the pure and the impure air. If there is disease of any kind in the lungs, it becomes still more befouled, and may need special antiseptics and disinfectants to be added to the inbreathed air. Deep inspirations of pure, cool air are of much value.

7. It is important to bear in mind that the carbonic acid given off from the lungs is not formed by the sudden combustion of the oxygen breathed in with the carbon in the capillaries, but the carbonic acid exists in the venous blood as it comes to the lungs, and the oxygen

inhaled is merely absorbed and carried onward, in a condensed state, with the blood current, probably only in solution.

Blood contains **much more oxygen gas** than could be held in solution by water at the same pressure and temperature. According to Magnus, the blood holds two and one-half times as much oxygen as is held by pure water.

8. As our design is always to add only the purest air, or what Linnæus calls habitable air, to this volume of residual air, we easily see what a mistake it is if the air breathed in is itself impure. The great strife of physical life is to secure pure air.

If in some way the air has been deprived of its oxygen, or any part of it, it fails of its first, great purpose; if in its stead it is already laden with carbonic acid, or dust, or foul gases, or organic particles, it is so far unfitted to bring back its quota of foulness from the residual air of the lungs.

Impure air is far more a cause of ill-health than most imagine. It is not merely that various lung diseases are caused thereby. The venous blood, laden with its used-up material, ready to be delivered and exchanged for the vital oxygen it needs, is not clarified as it should be, and the vessels are compelled to carry back again some of the used-up material. To some extent, the whole system is devitalized. Were it not that the human system has great power of endurance and adjustment, and is able sometimes to transfer to other organs the work which should have been done in the organ designed for it, life would be in constant peril.

As it is, health is often injured or vitally impaired

by such forced substitutions. The embarrassment may finally show itself in a diseased lung, or congestion of other organs, or impairment of function and a general **waste of vigor.**

9. There is a sense in which pure air is as much a **food** as anything that is taken into the stomach. If we are deprived of it, there is a real want of nourishment. The food taken into the stomach cannot be so well appropriated, and the blood fails to be the distributer of vitality that it should be. The result is a general loss of vigor. Either because of unremoved material, or of local irritation, minute deposits of ill-organized particles take place about the areoles of the lung in the form of tubercle, or the walls of the vesicles become thin and feeble, and hemorrhage occurs. Thus many a case of consumption is **started.** Deposit often takes place long before there is cough, or any of the signs of local impairment or constitutional disturbance.

10. The act of **respiration** is accomplished by the elasticity of the lungs and the mechanical arrangement of the **thorax,** or chest, in which they are contained. The elastic tissue of the air-cells is distended when the lungs are full, and then quickly contracts upon the air sufficiently to aid in expiration. The contractile power of the muscular walls of the bronchial tubes and the **cilia,** or hair-like plush upon the inner lining of these tubes, co-operates with the expulsive movement of the air-cells to remove the air and any liquids or solids.

This **contractile** and **ciliary** movement aids to remove all undue secretion, and is an additional aid in coughing, where the irritation is not too great.

11. The **chest walls** form a wonderful mechanical appa-

ratus for the reception and expulsion of air. The ribs are so attached to the vertebræ of the back-bone or spinal column as to be freely movable, and are so sloped toward the sternum or breast-bone as naturally to settle downward and forward. Crossing sets of muscles between the ribs are so arranged that the external intercostal muscles raise the chest while the internal intercostals depress it. Below the ribs, and between the lungs and the viscera of the abdomen, is a peculiar inner muscle, or set of fan-shaped muscles, called the **diaphragm,** which can co-operate in this action of the chest walls, or may remain quiet.

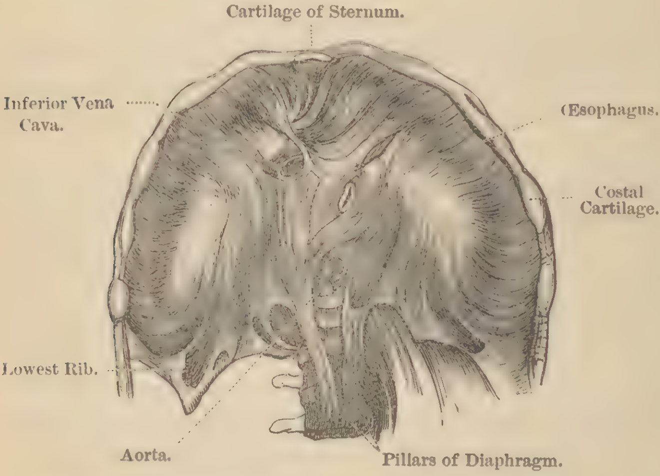


FIG. XX.—Showing the Diaphragm from the Abdominal side.

This figure will give some idea of it. It separates the cavities of the thorax, and the abdomen, and so

forms the floor of the one and the roof of the other. Its mobility aids in the act of breathing.

Although the two generally co-operate, we may have costal or chest respiration, or hold the chest nearly still, and have the respiration mostly conducted by the diaphragm and abdomen, and so called diaphragmatic respiration. Usual, gentle respiration is aided by the movements of the diaphragm.

12. The **muscles** of the **abdomen** also have an important service in connection with respiration. They much aid the action of the **diaphragm** and the chest, and are available, in various ways, as an aid during exertion. Usual respiration is from 13 to 15 times per minute, about 30 cubic inches of air being inspired and about the same amount expired. The mechanism of respiration is a little different in the two sexes. In men, the diaphragm and the abdominal muscles do the chief work, while in women the respiratory movement is mostly thoracic or costal.

It has been necessary thus to note these facts as to the mechanism of respiration, because so many embarrassments happen to this vital process.

Curvature of the spine, even when slight, as often caused by a habit of dropping of one shoulder, or in other ways, mars not only the symmetry of form, but interferes with the breathing. Pressure in various forms on the ribs, the breast-bone, or the adjacent muscles, is a still more frequent embarrassment. It may occur from the **mode of dress,** where the chest-walls are too tightly bound for free and natural expansion, or where the waist is girt about with various cords or swaddling-bands. Children, women, and adult men,

often suffer such embarrassments. Suspenders, if inelastic and often slipping from the shoulder, do not well distribute the weight.

13. A waist and chest coat fitted to the real form may have sufficient stiffness to help support the clothing, which depends even more on properly adjusted shoulder-straps. But, unfortunately, the more usual effort is to make the form fit its case. Many valuable improvements in chest or thorax dress are now secured, and it is either carelessness or perverseness to adopt injurious forms. Women are more dependent on chest breathing than men, and so should be even more careful not to impede the free and natural action of the chest. Untrammeled breathing is of so much more importance than an ideal form produced by artificial compression, that no one should attempt to sacrifice the former, especially as in the natural form of the body no mistake has been made, either as to utility or comeliness.

Posture is to the student a matter of no small importance. A chair sufficiently low, or a desk sufficiently high, or an occasional standing posture, will not only rest the muscles, but will aid much in the free play of the breathing apparatus.

14. Where there is any defective capacity of the lungs, or where there is flatness of chest or deficiency of muscular power, much benefit is often derived from exercise, or from gymnastic training under those who understand the way of accomplishing the object sought. There must be proper invigoration of the general system by good food and sleep, such exercise as gives play to the proper muscles and antagonizes errors of shape or habit, and such development of inspiration and expiration as

shall gradually increase the breathing capacity. **Sudden efforts** are never to be encouraged, but it is marvellous how, by proper drill and exercise, defects can be remedied and increased power secured. Physicians, and those who closely study returns as to the cause of death, aver that fully one-half of those who die between five and sixty years of age die from **impure air** or affections of the breathing apparatus. Parkes says that statistical inquiries into mortality prove, beyond doubt, that of the causes of death which usually are in action, impurity of **the air is the most important.**

15. Having defined pure air, and the relations of the lungs thereto, and how they are to be kept in working order, we pass next to notice how we are to protect them from impure air. If this be not done to a reasonable extent, no increase of capacity, and no riddance of undue pressure, will prepare them to receive a form of aerial supply for which they never were adapted or intended.

First of all, in the great open, we sometimes need to guard them against certain dangers that may arise. It is to be remembered that the nose, which has no muscular apparatus to close it, is the extension of the trachea or windpipe, and is the natural aperture for the inflowing of air. It is true that the mouth is accessory, and in running or violent exercise, is available, just as are other parts of the body which are foreign to the **essential act of breathing.**

An excellent little book was written by **Catlin,** the Indian antiquarian, with the title, "Keep your mouth shut." Its object was to show that the most prevalent cause of lung disease is the undue use of **the mouth** for **breathing purposes.**

The nose is admirably arranged by its divided and complicated passages, its hairs, secretions, and membrane, and its mode of jointure with the larynx, for straining and warming the air, for which purposes the mouth has no arrangement. **Bronchial irritation**, and other lung disturbances, frequently happen from undue use of the mouth in the open air, from the habit of breathing through it or of sleeping with it open.

16. In certain employments, where there is much dust, workmen are greatly benefited by keeping the mouth closed, and by aiding the nose in its work by occasional cleansing and sponging.

In the close streets and lanes of cities, on dusty roads, and in houses, shops, or assembly-rooms, we find the chief pollutions of the natural atmosphere. So great is the evil to cities from smoke, that in some of the manufacturing cities of Great Britain great effort is made to rid them of this nuisance by smoke-consuming and smoke-filtering apparatus.

As to our usual dwellings, school-houses, or other assembly-rooms, the first question that naturally arises is, how shall we know that the air is becoming or has become fouled to a degree inconsistent with healthful indwelling? Now that it is pretty well settled what amount of air-space and of pure air is needed for healthy breathing, where we find numbers of persons shut up in a room not answering to these conditions, and the additional sources of contamination afforded by lights, fires, etc., we may be quite sure that the air is being unduly deteriorated. The next practical test is, how the air seems to one coming in thereto out of the open air. To such, there is a sensation of stuffiness or closeness

not so readily perceived by those in the room, which is quite an unmistakable indication.

As the condition of the air as related to health has already been considered, and as under Heating and Ventilation it will also be discussed, we need not enlarge upon it here.

17. **The Voice and its Health.** — The **human voice** is so much a part of expression, of emotion, and can be educated so much like one of the senses, that it would not be surprising if eventually it should be classified as a special sense. Its apparatus is as wonderful as that of the eye or the ear. While utterance is a more complex process, there is a voice as well as ear and eye attent, and will and culture show its marvellous capacities. The **larynx**, or that part of the trachea or windpipe which contains the vocal cords, is the essential organ. While the lungs form the bellows, the pharynx, mouth, and nasal cavities aid in the resonance.

The **larynx**, in its upper part, is a cylindrical box of a triangular form, growing narrow and cylindrical below. It is formed by nine cartilages, connected by ligaments and moved by nine muscles, of which eight are in pairs. The thyroid cartilage is the largest and most prominent, as it unites in front at a projecting angle, and forms the bulge in the trachea generally known as **Adam's apple.** The tradition is that it was so called because of a vagrant fancy of the Orientals that it resulted from eating the forbidden fruit.

18. The **epiglottis** is the cartilage behind the root of the tongue, placed above the glottis so as to leave freedom for respiration. While the larynx is elevated in swallowing, the epiglottis falls over the glottis and closes it, and

at the same time acts as a lid to cover the glottis whenever the œsophagus, or tube to the stomach, is being used. While not a direct part of the machinery of the voice, it affects the vibratory motion of the air, and probably contributes to the timbre.

The **hyoid** bone, to which the larynx is suspended, ascends and descends with it, and is in control of ligaments and muscles. As we look into the interior of this wonderful music-box, we find it a movable labyrinth, with two folds of membrane stretched horizontally across it, known as the true or inferior vocal cords. Besides these, there are two other folds parallel to and above them, termed the superior or false vocal cords, which are not known to contribute directly to the formation of the sounds, but which aid in the adjustments.

19. The muscles are so arranged as to give to the cartilage great variety of movement, and great variation in the shape of the larynx and the tension of the vocal cords. The **larynx** has an abundant supply of minute vessels and nerves, and some small glands which lubricate the epiglottis and the part above the cords. The **pharynx**, or part of the throat on either side of the **uvula**, or palate, the pillars of membrane on either side, forming an arch, the tonsils, the nasal fossa, the cheeks, the mouth, the lips, the tongue, each and all have varying parts to perform.

20. The mode in which the voice organ acts has been variously compared to that of the violin, the flute and reed and pipe instruments. In some respects it combines them all. The sound results from vibrations of the vocal cords and ligaments, the same as occurs in reed instruments from elasticity of the reed and the

varying length of the tube. The **pitch** depends on the tension of the vocal cords by which the size of the glottis, or inner larynx, varies, and on the ascent and descent of the larynx, by which the vocal tube shortens and lengthens.

In the effort to produce sound the true vocal cords draw nearer to each other, and the air, passing through, sets the vocal ligaments in vibration. Such flexibility in every part and such variety of air, force, tension, and vibration, are secured as to give an almost unlimited variety of tone, pitch, and intensity. There is a wonderful range in the adjustment of the vocal cords, which is so increased by practice that a singer has been known to have a control that could determine the contraction of the vocal ligaments to one-fifteen-thousandth of an inch.

The quality and compass of voice which have been acquired is as wonderful as any of the attainments of the senses. We once stood near the outer door of the immense hall in which Mme. Parepa Rosa sang in New York city, and in the midst of the anvil chorus of hundreds of singers and all varieties of instruments, could distinctly catch her warbling notes, clear and shrill beyond and above the rest. The voice of women, although different from that of men, has no variation in its inner apparatus, except that the larynx is about one-third smaller. The tissue is thinner and more elastic, and so gives a more acute pitch.

21. There is no portion of the body that admits of more cultivation than the apparatus which produces voice, and none that oftener suffers from imperfect development or care. The **hygiene** of the voice often has to

do both with health and with success in life. Articulation and reading are among the most important early educational exercises. Early training in singing has the additional advantage that it educates the ear and voice together, and so gives taste and power of expression.

The child should be practised on notes that it can produce without much effort, and the exercises should not continue for more than fifteen or twenty minutes. The least vocal fatigue should be avoided.

22. The modification of **timbre** and **pitch** of voice, which takes place in growing girls and boys, causing, for a time, a hoarse or shrill voice, is to be so far recognized that the voice shall not, at this period, be over-exercised or over-trained. The larynx does not acquire its full development before the age of twenty years, and may be so affected that any over use may lead to serious impairment.

The skilled teacher always has careful regard to any changes or embarrassment that the voice has at any time, and will see to it that no unwise attempt is made to recover its timbre or compass. The highest and lowest notes are especially to be avoided by many. The abuse of the acute sounds injures many voices. Independent of vocal exercises, which, if properly conducted, are usually of advantage, the voice is not infrequently injured by loud calling or screaming.

23. It is always unfortunate to have to use the voice in speaking, singing, or much talking, when the throat is irritated, or when there is huskiness or hoarseness. Chronic laryngitis is often produced in this way, which sometimes becomes permanent, and is always slow of

recovery. Entire rest, the breathing of moist, warm air, and the use of some emollient to soften the parts and make up for the lack of secretion, are always the part of prudence. The use of the voice has such relation to mental exercises that all that relates to its preservation and quality must be guarded with judicious care. Even the temper can be restrained by the measured and low-toned voice.

24. Right habits of breathing, care of the breath, the mouth, the teeth, and of all the throat, and of the nose, have much to do with the perfection of the voice. Dr. Durant well says: "The purity of the voice results from the ease with which the air is expelled from the lungs; the precision with which the varying tensions of the vocal cords are made; the absence of all obstacles to the passage of the air through the bronchi, larynx, mouth, and nasal fossæ; the condition of the membranes lining the vocal apparatus; the art with which the sonorous wave is modified in the buccal and nasal cavities before reaching the external air; and, finally, the absence of all causes which might oppose the action of the expiratory and inspiratory muscles, as well as those which move the larynx itself."

25. What has already been said as to the preservation of the natural contour of the chest, as well as of the care of the breathing and digestive organs, is thus emphasized. There must be **free action** of the entire respiratory apparatus as well as of the muscles adjacent to and below it. Unnatural modes of breathing are not infrequently acquired, and must be corrected by a return to right practice. The ribs, the diaphragm, and the ventral walls have each a natural part

which they instinctively perform, unless hindered by dress or by ill-acquired habits. Singing involves fuller and more rapid respiration than is usual. The scope is from 6 to 30 respirations a minute, the average being from 16 to 18. Thus the usual respiration of about 500 or 600 cubic inches of air per minute may be increased to 800 or 900 per minute.

Nature has provided for this by its residual and tidal air, and its vastness of vesicular lung-compass, but there must be culture and adaptation. What is true of singing is measurably true of other exercises of the voice, as reading, elocution, talking, and shouting. All need training by natural methods.

26. The proper use of the wonderful organ of speech is for general as well as local health. On the other hand, over-strain, irritation, exposure of the inner throat to severe cold, to heavy air, to sudden chilling by ices, to over stimulation with troches, is often the irritating cause of both local and general disturbance of health. Even children in school know something of the nervous tension and exhaustion of recitation and of vocal action. **Foul air**, too, often adds to the injury. Although talking and singing and speaking do not impress us as **labor** so much as do other exercises, yet rapid and exhausting work is being done in the larynx amid the air-cells of the lungs and the minute vessels of the capillary circulation. There must be good food, good sleep, and that habit of quiet breathing and free chest expansion which are in contrast with nervous inhalation or breath-catching, which betokens exhaustion or an ill habit of breathing. While the loss of voice is rare, its impairment is frequent.

27. It is to be remembered that for very many the **voice,** whether in the well-modulated tones of conversation or in the rhythm of music and song, is a chief possession and accomplishment, and as such is to have all that hygienic care which is essential, not only to its quality, but to the vigor of the marvellous and vital organs with which it is associated. A physician of London has acquired a world-wide reputation for his minute care of the throats of singers. The treatment is far more hygienic than medicinal, consisting in the most rigid attention to food, sleep, diet, care of teeth, mouth, throat, nasal fossa, the larynx, the chest, the lungs, the body as a whole. The voice itself thus becomes all the more admirable because it is the expression of perfect health of body and of mind, of soul and emotion, of all that constitute true life, and so gives utterance to a harmony of the whole nature.

Chapter XI.

DIGESTION: ITS ORGANS AND METHODS.

THE next demand made upon the outer world for the sustenance of human life is for **food**. Just as the air is needed to go down to the lungs, and there re-vitalize the blood and remove the used-up material; so there is an arrangement by which food goes into another part of the system, has extracted from it what is necessary for the support of life, and then receives in its course much spent material for rejection. In the one case as in the other, the transforming and supporting material enters into the blood through a minute system of small vessels.

It will be necessary, in a brief way, to outline the apparatus through which the preparation and transfer of this food is accomplished.

The following diagram gives a view of various organs, so that the relative position of the digestive apparatus may be seen.

2. The receptacle into which the food is received is known as the **alimentary canal**. Commencing at the lips and mouth, and continued into the pharynx and back part of the mouth, it soon becomes that part of the tube known as the **œsophagus**, gullet, or food-pipe. This is a flexible tube behind the windpipe, and about nine inches in length. It then expands into a pouch known as the **stomach**, which, after being con-

tracted at its lower orifice, is continued into a tube known as the **small intestine.** This, again, expands into the **large intestine.** The stomach of a full-grown man is, when full, about twelve inches in length and four inches in its greatest diameter, and has a capacity of about one quart. The entire length of the intestines

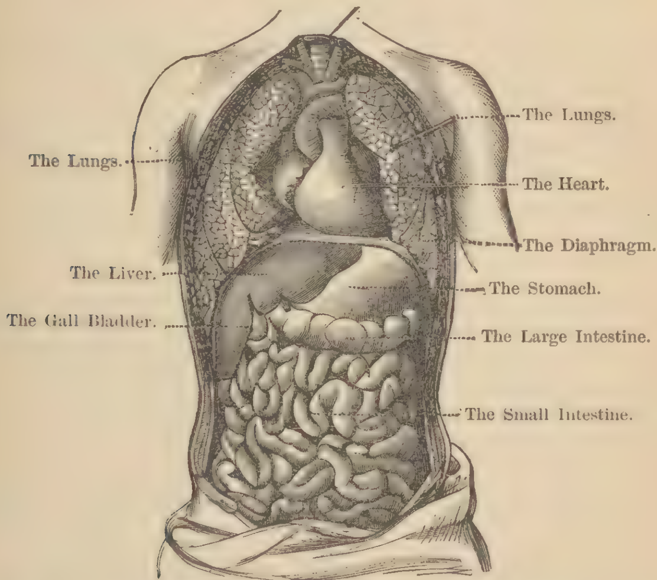


FIG. XXI. – The Relative Position of the Chief Organs in the Chest and the Abdomen.

is about twenty-six feet, of which the large intestine constitutes six feet. This flexible pipe is arranged in folds, and has connected with it various glands and tubes which perform a part in the digestive act.

The following figure shows the course of the food, with some of the accessory organs, as far down as the upper part of the pelvis.

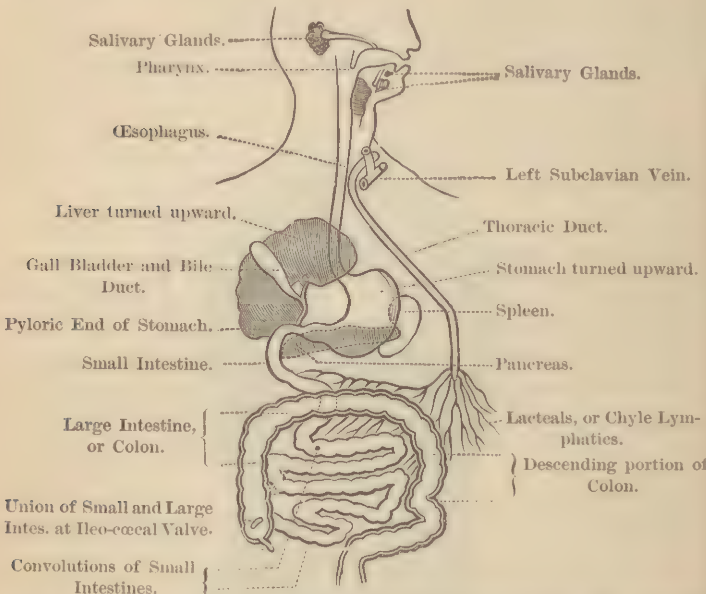


FIG. XXII.—Showing the Digestive Apparatus, and the Course of the Food.

3. The **mouth** is the irregular cavity which forms the beginning of the alimentary canal, and which is intended for the mastication and mingling of the more solid food. It is lined by mucous membrane. It contains the tongue, which, by its muscular arrangement and shape, is well-fitted to aid in the movement of the food. Both the mouth and the tongue have their lining or mucous membrane studded with **buccal** glands about

the size of millet-seeds, which, through their ducts, pour out **saliva,** and so add to the moisture of the food. Most of the saliva is supplied by the two glands under the tongue known as the **sub-lingual,** two under the jaws known as **sub-maxillary,** and two just at the bend of the jaw and below the ears known as the **parotid** glands. The ducts of the parotid glands open nearly opposite each second, upper, molar tooth; those of the sub-maxillary glands, under the tongue at its junction with the under surface of the mouth; and the sub-lingual glands, quite near to these. These fountains of saliva, or spittle, are furnished not only to moisten the mouth and the food and render it fit for mastication, but these juices help to make the starchy matter of foods soluble by aiding in its conversion into sugar. Starchy foods cannot become nutritive until this change is wrought in them. It is because of the absence or scarcity of those juices which especially affect starch, in young and unweaned children, that starchy foods are not so good for them.

The combined juices of the mouth are slightly alkaline. From one to three pounds, or, on an average, over a quart per day, is secreted by an adult. The amount varies much according to the amount and dryness of the food and the degree of mastication.

4. Here is manifest the importance of deliberate and thorough **mastication.** Eating should be one of the most deliberate and thorough of all the duties of life. A minute division of the food in the mouth, and its mixture there with **air** and **with saliva,** are the first essentials to good digestion. The rest of the digestive track, if called upon to make up for defects in the first process, will eventually show the ill-effects.

Besides this process of mixing, the mouth has been fitted for the thorough grinding and crunching of food. The muscles that operate the lower jaw are so arranged that great force can be exerted, and with such change of direction as shall give advantage for thorough division. Biting, grinding, crushing, moistening, besides the mixing with air and digestive juice, are all to be accomplished in the mouth. Neglect of any of these is the beginning of wrong-doing to the whole digestive apparatus.

The entire arrangement of **the teeth** is admirably adapted for their purpose. In order that there may be

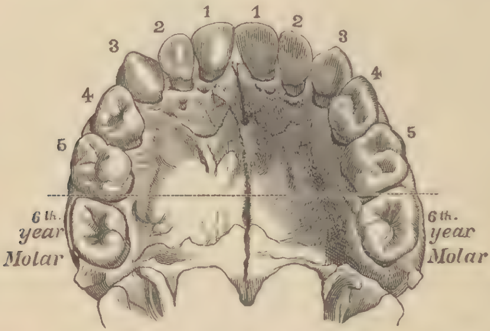


FIG. XXIII.—The Teeth, showing temporary set of the upper jaw and the 6th year Molars of second set.

no failure, a **reserve set** is furnished to take the place of the twenty of the **temporary** set which answers for earlier life.

5. The **permanent teeth**, thirty-two in number, are arranged in the form of **arches** in the upper and lower jaws. The sixteen teeth of each jaw have four types or

shapes, and are therefore known as the four incisors, or cutting teeth; the two canine, or tearing teeth, the four bicuspid or double-pointed crowns, both for cutting and crushing, and the six molars or grinders. These again are so varied in their surfaces as to give every advantage for the reduction of food.

6. What are known as the **sixth-year molars** deserve a special notice, because they are so frequently confounded with the first set of teeth. The reason of this is that these back teeth of the upper and lower jaw on either side make their appearance before any of the first teeth are shed. But if neglected, as they too often are, they are early lost or never replaced. When you are able to count a row of eleven or twelve in each jaw, you may be sure that the last molar on either side belongs to the second set. Teeth, like bones, are not fully solidified in early childhood, and even the second set needs to be allowed to acquire hardness, instead of being converted into nut-crackers. It is a good plan to have a dentist look at these first permanent teeth as soon as they are fairly through, so that any possible tendency to decay may be checked. These **sixth-year** molars have been given with the plate of the **temporary** teeth in order to attract attention to them.

7. The following table gives the order of the full upper set of teeth, which have their sixteen opposites in the lower jaw.

The permanent set appears about as follows:

First molars	5 to 6 years.
Central incisors	6 to 8 "
Lateral incisors	7 to 9 "
First bicuspids	9 to 10 "

Second bicuspids	10 to 11 years.
Canines	11 to 13 "
Second molars	12 to 14 "
Third molars, or wisdom teeth . .	17 to 22 "

8. In good constitutions, when well taken care of, and when used as they should be for mastication, the permanent teeth last a lifetime. But if not cared for as they should be, the membrane of the mouth becomes affected by the condition of the stomach, the gases of imperfect digestion come up and act upon the teeth, and there is premature loss. In cases of perfect digestion and of inheritance of good teeth, we find that they are generally kept until old age, without the necessity of any special care.

But conditions, as we have them, are so artificial that there is, as a rule, need of careful attention to the teeth. Rinsing of the mouth after each meal, and on rising and going to bed, are most important. The brushing of the teeth, so as to remove any particles of food, is also a valuable aid. Slight decay of the teeth, and closeness or irregularity, not only do harm directly, but indirectly, by the retention of small particles of food that hasten to decay, and so cause bad breath and foul air.

When there is a tendency for **tartar** to collect about the teeth, care must be taken that not merely the points of the teeth are brushed, but that they are touched by the brush all along the gums. Decaying teeth should either be filled or removed. In order to preserve the contour of the jaw, it is not deemed wise to pull many of the first teeth, but they can be cheaply filled with temporary filling.

9. The care of the **teeth** and the **chewing** of the food are so much within the reach of personal habits, and are so essential to good digestion, that not only should children be advised, but they should be **trained** into methods of care.

Brushes are of much value, but are intended for rubbing rather than scrubbing the teeth. There is no need of elaborate powders. Precipitated chalk or orris-root powder answers the purpose. Thorough attention to the mouth, in order to keep its membranes and the dental arches in the best condition, secures not only a sweet breath, but good health. Any oversight here is a neglect of that part of the digestive apparatus which we can most easily reach.

10. The **food** having had proper reception in the mouth, and having been thoroughly mingled with its juices, and masticated by its dental apparatus, is now by a peculiar muscular and peristaltic action carried to the funnel-shaped opening behind the mouth, known as the pharynx, and so on to the gullet, or œsophagus, which ends in the upper and left side of the stomach. It there comes to an organ having wonderful arrangements for movement, and a juice is freely poured into it from various glands, follicles, and ducts in the walls. A healthy stomach can, if need be, furnish three gallons of digestive juice each day.

The thin, acid fluid thus furnished is known as the **gastric juice.** The **proteids or albuminoids** of the food, as they are called, are dissolved and absorbed directly by the veins of the stomach, which are arranged with thin walls so as to admit of this absorption. The water is also freely taken up. So much of the starch of the

food as has been well mingled with the saliva, so as to be converted into sugar, is also disposed of here.

11. The flow of this gastric juice is greatly influenced by mental and nervous states, by exercise, by kinds of food, by appetite, etc. Great anxiety or excitement will partly suspend the action of the stomach. As watering of the mouth takes place over food, so with a strong desire for food there is an increase of digestive juices. Fatigue, or over distension of stomach, interferes with the flow, while exercise and a sensible meal increases it. Condiments and stimulants momentarily increase it, but when continuously used they tend to corrugate the folds of the stomach and to enfeeble its secretive functions. Thus many stomachs are greatly injured by **alcohol** and by sharp **condiments.**

We can learn a great deal as to what solid and liquid foods to use by studying how they are dealt with in the digestive canal. The muscles of the stomach are so arranged as by their contraction and relaxation to agitate the food, and by a partial onward movement to push it out into the next part of the digestive canal.

12. The **stomach** is of an elongated shape, and has such a pouch-form as to be pressed out when full. Sometimes palpitation of the heart results from its over-distension. The point where the foods enters it is called the **cardiac** end. The lower end is the **pylorus,** so called because it is closed like a gate, admitting and retaining the cruder portions until, at the close of the digestive process, or its partial suspension, it relaxes aud lets through the denser material.

While the stomach is so important an organ of digestion, it is to be remembered that it deals with only a

part of our foods. It does not act on **fats** or **starches,** but stops the action of other juices upon them.

The pepsin and hydrochloric or lactic acid of the gastric juice acts as a solvent on the proteids or albuminoids to be hereafter described.

These are so acted on that a great deal of the fluid which results from stomach digestion is at once absorbed through the delicate meshes of the multitude of minute vessels of the stomach into the blood current which the gastric veins gather into the portal vein, which carries it to the liver.

13. All the rest, in the form of an acid gruel called **chyme,** is passed into the next portion of the digestive track. This mixture is somewhat varied by the food, but consists chiefly of the **amyloids,** or starchy foods, not yet converted into sugar, and the albuminoids, which have not been absorbed, together with a little sugar, saliva, and gastric juice, and the indigestible parts of the food. The digestive tube which receives the chyme is about twenty feet in length, and is called the small intestine. Its parts are generally spoken of as the **duodenum,** the **jejunum,** and the **ileum.**

So soon as the **chyme** has passed the pyloric or lower orifice of the stomach, it meets the three fluids known as the **biliary,** the **pancreatic,** and the **intestinal,** and the name is changed to **chyle.** The biliary or hepatic juices come to it by a small duct, which is the united duct from the liver and the gall-bladder. It enters about three inches below the pylorus. It empties into the digestive stream from two to three pounds of fluid each day. This fluid has a twofold character. It is the used-up material which has been separated from

the blood in the liver, and therefore is of the nature of an excretion or excrement; it also contains materials for neutralizing the acid of the gastric juice, and for converting fats into an emulsion. It is called **bile**.

The substance called **glycogen** is made in the liver from the digested materials brought to it by the portal vein. It tends to change into glucose-sugar in the presence of an animal ferment. This is a part of the digestive process, and furnishes respiratory fuel or food.

14. The **pancreas**, or "sweet-bread," is a small gland close to the stomach, and has a duct at its terminus which enters the intestine so near the bile-duct as to seem to form a common duct. The entrance is not far from the middle of the bend of the duodenal portion of the small intestine. The pancreas secrete about one-half pint of juice a day. It acts on starchy substances and on the albuminoids or proteids, and aids the digestion of fats. Besides these fluids from glands or organs, the mucous membrane of the intestine is provided with numerous small and mostly simple glands which pour into it a secretion of less defined function, which is spoken of as the intestinal juice. All these liquids unite to extract and appropriate from the chyle or chyme the nutrition it is capable of imparting. The digestion of albuminous matter is completed, the fats are emulsionized so as to be appropriated by the system, and the starches fully converted into sugars.

15. These constituents of food, thus acted upon and prepared, are absorbed by the veins and by small tubes known as **lacteals**. Those taken up by the veins of the intestines follow the same course as those taken up by

the veins of the stomach, and enter the portal or liver circulation first. The other portion consisting mostly of emulsified fats, passes into the **lacteals**, and is gathered into a special tube known as the **thoracic duct,** and so passes into the left subclavian vein, and to the heart, and becomes a part of the blood, as before noted.

16. "The lower part of the thoracic duct is dilated, and is termed the receptacle or cistern of the **chyle.** It receives the lymphatics of the intestines, which, though they differ in no essential respect from other lymphatics, are called **lacteals,** because they are filled with a milky fluid, which is termed the **chyle.** The **lacteals** or lymphatics of the small intestine not only form networks in its walls, but send blind prolongations into the little velvety processes termed *villi*, with which the mucous membranes of the intestines is beset. The trunks which open into the network lie in the **mesentery** or membrane which suspends the small intestine to the back wall of the abdomen. The glands through which these trunks lead are hence called mesentric glands."

17. The movement of the fluid along the intestines is accomplished by the progressive and worm-like action of the muscular coat of the intestines, which is called **peristaltic** action. The alkali of the bile neutralizes the acid, and the bile and pancreatic juice emulsionize or sub-divide the fats into very small particles, which are held in the fluid much as cream is suspended in milk. When the chyme-acid is neutralized, the conversion of starch into sugar, which is mostly suspended in the stomach, takes place rapidly under the action of the biliary, pancreatic, and intestinal juices.

The fluid is called **chyme** as it passes from the

stomach, but as it thus becomes acted on is called **chyle**. It is moved along by the contractile action of the small intestines, and the dissolved matter is absorbed by the vessels of the **villi,** as before described. The minute particles of fatty matter, by a little different squeezing process, find their way into the vessels. So between the blood-vessels and the lacteals the **nutrients** contained in the food are appropriated. The semi-liquid material, thus deprived of the **peptone,** or digested albuminous matter; of the soluble amyloids, or starchy materials converted into sugar; and of the sugars and fats, passes through a fold of the intestine, which forms a valve known as the ileo-cæcal valve, which marks the change from the small to the large intestine. Here there is, in the upper part of this intestine, an acid reaction, and probably some remaining portions of the food are appropriated. Then the portion not appropriated as food, and the excrementitious secretions, pass on to their separation from the body.

18. While it is not necessary to present all the minute details of the digestive process, this much is needful to be known, in order that we may speak intelligibly of the hygiene of the digestive track. First of all, none of the organs concerned in digestion need, or admit of, artificial **pressure.** The stomach is intended for expansion, and where food is taken the extension of its surface is a part of the method by which the flow of gastric juice is increased, while its rolling and slightly peristaltic motion is a mode of mingling and digesting the food.

Cords or bands, or stays of any kind, pressing too hard upon it, interfere with its size and movement.

Physicians distinctly recognize forms of dyspepsia in which there is either constriction, or irritable distention of the stomach and muscular spasm, or other interference with its normal motions. Pressure upon it also causes it to press unduly upon adjacent organs, and so may irritate and disturb them.

The **diaphragm**, which is the movable muscular partition between the thorax and the abdomen, and has much to do with breathing, often suffers from undue pressure. Hiccough is often the sign that it is pressed upon by some distended organ, or that some form of nervous irritability is conveyed to it.

The **heart** is not infrequently affected by such pressure, and also by the over-distention of the stomach by food, liquids, or gas.

The **liver** is so large an organ, and has so much to do in the digestive process, that it, too, may suffer from undue compression. It is the largest gland in the body, weighing about four pounds, and sending into the intestine each day an amount of fluid one-half of its own weight, which passes into the upper intestine just below the stomach. It is located where undue pressure about the waist has a tendency to press or displace it.

19. But the **great injury** that comes to the digestive apparatus is from taking into it materials either too frequently or not frequently enough, or not containing the right quantity of food rightly prepared. **Frequency** of eating should be regulated by age, or by the demands made upon the system. Growth is of itself a demand. In the growing period, digestion and circulation, waste and repair, are more rapid than at full age. Parkes

says, that in the period of growth the utmost limits between the meals should be four hours. The heartier meals should be in the morning, and not later than six o'clock in the afternoon; but no one should go to bed hungry.

In the selection of food, we are guided much by appetite. But as appetite may be artificial, we also need to find out what are the foods which study and experience have shown to be essential. By the aid of chemistry, and of inquiries into the physiology of digestion, great progress has been made in the last twenty-five years in the knowledge of foods, such as has greatly added to their variety and adaptation, and such as ought to aid much in the promotion of health.

It is easily shown that the stomach of man is only intended for such food as is **liquid** or semi-liquid, or such as has been reduced by **mastication.** It must contain in it those ingredients which it is known the system will demand from it, or such as it has the power by its own additions and changes of converting into nutritive material. We easily find that constant dependence upon liquid foods is not desirable, except in certain enfeebled conditions of the stomach.

The **temperature** at which digestion goes on is from 98° to 100° F. If this is reduced by cold food or **ice-water,** so as to interfere with quick reaction, digestion does not begin, or is interrupted. When the stomach is in any way enfeebled in digestion, some **warm drink** just before or with a meal is often found of service. The kinds of food, and the preparation of foods as to cooking, will be considered elsewhere.

20. The **quantity** of food depends on the demands

of the system, and is therefore variable. Because there is an approximate law, we generally eat three times per day. But there may be days when four meals are needed, just as much as three or two are needed on other days. Food and sleep are relative to each other, so that persons who sleep well and long do not need so much food as those who spend less time at rest.

The taking of a large amount of **indigestible** material with the food tends to disturb the process of digestion. Nature has provided for the disposal of certain parts of foods which are not convertible into blood or tissue, but not to such an extent as to warrant the use of articles having in them no food material. Cast-off matter consists not so much of that which has not been digested as of that which is separated from the system in the **process of waste and repair.**

21. It is easy to see how the membrane of the intestinal track can be injured by putting into it substances which interfere with its natural processes. If we take very hot **condiments** into the mouth we are conscious that they act unnaturally and unfavorably upon its membrane. If they burn it so that we have to cool it, we find that a condition has resulted which requires a reparative or healing process. If we keep on putting the same material in the mouth until it becomes used to it, what we call **toleration** is established. This does not prove that in this continued use, without the **discomfort** had in the first instance, we are doing no harm. While the harm is not so declarative, and while it may be modified by the adjusting powers of the human system, inquiry into the effect upon internal organs and their functions leaves no doubt that vital **force is** impaired.

The **digestive track** thus comes to endure cayenne-pepper, tobacco, alcohol, and various other substances, which, when first taken, are irritative to the membranes, and which are not needed. No one can study the minute anatomy and physiology of the wonderful apparatus of digestion, and see the effect which improper foods and drinks have upon its delicate structure, without realizing that we must give to the system, and to each physiological process of it, such material as it was intended to operate upon. If it is found that any fluid placed on the mucous membrane of the stomach engorges its minute blood-vessels beyond the usual fullness for the digestive process, and constricts the various follicles and minute gland-ducts of the stomach, so that they can no longer pour forth, in their natural method, the juices needed for digestion, the proof is positive that there is interference with good digestion.

This has been frequently enough proved as to certain sharp-tasting substances, and so-called **condiments**, and as to **alcohol.** In addition to this it has been shown that so-called moderate drinkers eventually have impairment of the vital acts of digestion, and that the stomach, the liver, the intestines, and the kidneys register effects which are prejudicial to health and long life.

22. The **effect** of materials taken into the stomach is sometimes to be inferred from the immediate results; sometimes from the results secured by a systematic plan for a long time in which, by increase of appetite, or of weight, or by improved health, or the opposite of these, we are able to prove the influence of the article used. Frequently where there is apparent advantage

for a time, we are able to show by the impairments of organs or functions, or by an early decay of vital powers, that what seemed of temporary advantage, or at least tolerable, has proven to be injurious.

While the appetites and preferences and prejudices of men, or their insufficient facts and inconclusive reasonings often lead to error, yet it is encouraging to know that there are many careful and candid and competent observers who collect evidence and give it logical consideration, and so secure for us reliable results.

When we come to consider Foods, it will be apparent that nature has made an adaptation between the digestive organs and food materials which should guide us in the choice of foods and the methods of their preparation.

Chapter XII.

OUR FOODS AND THEIR USES.

IN the study of the human system, for an inquiry into the best methods of keeping it in health, we necessarily have occasion to find out whence it obtains the material which it is able to change into vital force. We have found that its nutrition is chiefly derived from the blood, and that this obtains its supply from materials furnished in foods and drinks that are conveyed to it through the digestive apparatus.

As we ascertain the various constituents of which the body is composed, and by which it exerts its force, we inquire whether these are furnished in the foods and drinks used, or whether there is a chemistry of digestion which converts these into food. We could not be at all sure as to our views without some examination of the foods and drinks which enter into the system. If we find in these the very substances which are found in the human system, and which we there find convertible into life-force, and are able to trace the modes of appropriation, we are enabled to recognize their true value as foods.

The inquiry is the more important because it enables us, in a large degree, to estimate the value of foods and drinks, and so to determine the indications for their use. As the value of the food also depends on its preparation, and on the way in which it can be trans-

formed in the stomach, we will need to look briefly into modes of preparation as they are carried on outside of the body in the processes of division and in cookery, as also to those changes which are wrought within, and which, by converting one substance into another, contribute to life and health.

2. The division which has been generally accepted, of materials contained in the system, is into two classes. First, that which furnishes the substance for the body itself; and next, that which furnishes the heat which maintains the temperature of the body. These are often distinguished as flesh-producing and heat-producing foods. The chemists term them **nitrogenous** and **non-nitrogenous foods,** nitrogen being a chief constituent of the flesh or body-forming foods. If we could accurately draw the line betwixt the two, it would be expressed as follows:

I. **Nitrogenous:**

Flesh-forming.
Muscle or tissue repairing.

II. **Non-nitrogeneous, or carbonaceous:**

Fat-forming.
Heat-producing.
Force-giving.

The **first** includes not only the material of which the body is made, but also that which is needed to repair the wastes of the body. The **second** includes the food which produces muscular and intellectual strength for work.

The nitrogenous matters are so largely represented by albumen, of which the white of eggs is an example,

that these are sometimes called the *albuminoids*. They are also called protein compounds (Gr. πρῶτος, *first*), and are the flesh-forming and muscle and tissue repairing foods. These exist largely in meat, and in some vegetables, as beans.

Fats, and also **sugar** and **starch,** belong to the opposite, or carbonaceous class. The latter are sometimes called **carbohydrates,** and are very important. They are convertible into heat and force, and reappear but little in the organic body.

3. The chief examples of each of these divisions of food may be stated thus:

I.
- Albumen, as in eggs, beans, etc.
- Gluten, as in wheat and other cereals.
- Casein, as in milk, cheese, etc.
- Fibrin, as in meat, fish, etc.
- Gelatine, as in jellies, etc.

II.
- All fats or oils.
- Starch, as in potatoes, rice, grains, etc.
- Sugars, as in fruits, sugar-cane, and glucose.

These two classes of foods, with water as the great conveyancer or medium of exchange, and with a few alkaline or other salts, are indispensable as material for the body and for the exercise of force.

4. The **salts** are chiefly the phosphate of lime, which forms the basis of the bones, and phosphates, sulphates, and chlorides of potassium and sodium, with a little magnesium and iron. Common salt, or chloride of sodium, is the only one which, as a rule, has to be supplied in addition to the ordinary foods, and chiefly as an aid in digestion and assimilation. These, for

distinction, are called **mineral** compounds, while the others are called **organic** compounds. Yet, as we have seen, the **organic** compounds are generally the media or conveyancers of these **mineral** compounds.

It is not incidental that the organic compounds of our bodies and our foods are found to be the same, for the latter become foods by virtue of the demands of our bodies. In an average man, weighing about 150 pounds, chemists have reckoned the water to be about 90 pounds; the nitrogenous matters or albuminoids, 27½ pounds; the fats, 23½ pounds; the mineral matters, 8½ pounds, and the carbohydrates, etc., a trace.

Milk, as containing all these aliments in their readiest form, is a representative food.

5. The distinction between the **flesh-forming** and the **heat-producing** foods cannot be perfectly drawn, since under some circumstances the one is convertible into the other. Most foods contain some proportion of each. As a rule, those foods which contain each about in the proportion required by the system in the state of health, practically are found to be the foods in most universal use. In digestion, the **starches** are converted into **sugars,** and thus aid considerably in producing animal heat and fat. The heat-producing power of **fat** in its natural state is about twice as great as that of **starch** or **sugar.** An attempt to reckon the value of foods precisely from the proportion of their constituents fails, because neither class of foods is entirely exhausted of its energy or power in digestion, and because the conditions of the system and various self-contained powers of the temporary supply modify the close relation between the constituents of foods

and of the body. Those, however, who have studied these subjects, have not confined themselves to theoretical considerations, but with these in view, and with comparison made by the actual weighing and assortment of foods, have been able to deduce many valuable guides as to their effective and economical use.

The daily requirements of the body may thus be stated:

	Nitrogenous, or Flesh-producing Food.	Carbonaceous, or Heat-producing Food.
During idleness	2.73 ounces.	20.60 ounces.
During routine or regular work	4.48 "	26.44 "

The need during illness is equivalent to a little over two pounds of wheat-bread, lightly buttered, and that during work to three and one-half pounds of bread. This gives, for a working-man, a need of about six times as much of the heat or force producing as of the flesh or tissue producing foods.

Professor Huxley has thus given his conception of the constituent elements of a model human body, and of its daily demands and losses in the full exercise of its physiological functions:—

A full-grown man should weigh 154 pounds, made up thus: muscles and their appurtenances, 68 pounds; skeleton, 24 pounds; skin, 10½ pounds; fat, 28 pounds; brain, 3 pounds; thoracic viscera, 3½ pounds; abdominal viscera, 11 pounds; blood which would drain from the body, 7 pounds. This man ought to consume per diem lean beefsteak, 5,000 grains; bread, 6,000 grains; milk, 7,000 grains; potatoes, 3,000 grains; butter, 600 grains; and water, 22,900 grains. His heart should beat 75 times a minute, and he should breathe 15 times a minute. In twenty-four hours he would vitiate 1,750 cubic feet of pure air to the

extent of 1 per cent; a man, therefore, of the weight mentioned ought to have 800 cubic feet of well-ventilated space. He would throw off by the skin 18 ounces of water, 300 grains of solid matter, and 400 grains of carbonic acid every twenty-four hours, and his total loss during the twenty-four hours would be 6 pounds of water, and a little above 2 pounds of other matter.

6. Without going into extended detail, it is very easy for any one to see how important are the studies of the food-values of different articles. We have come to know, very nearly, what are the requirements of the human system as to the material it is seeking to obtain from without.

We are able, in many substances, to identify the precise materials which are thus required for the body, and measure the amount which is stored in each kind of food. We are also able to determine whether they are in the simple form for a ready **digestibility**, or whether they are so combined as to embarrass their ready appropriation by the system. In many cases, like that of **starch**, while not finding the precise article required by the system, we find an article readily convertible into the one required, and can precisely determine the method and conditions of its conversion. We are also able to estimate circumstances in which. not only by excessive work, but by loss of sleep, or foulness of air, or special states of health, extra demands are made upon the system, which must be met by corresponding increase of food.

7. We find also that many **vegetables** have in store the very foods that are contained in flesh. Although there is a sense in which flesh is an advance in the process

of digestion and a concentrated food, since the animal is an extract from the vegetable, yet, as in albuminous substances, for instance, we find some vegetables equally rich, and giving up their food very readily to the system. Thus the common haricot or kidney-**bean** and the lima-bean have a large store of such food, and are very valuable as a substitute for meat. **Indian-corn,** well-cooked, has much of the strength of meat, and is rich in oil.

While from the composition of each food it is not easy to state what amount should be consumed by each person, and while, therefore, it is not worth our while here to repeat the elaborate tables which have been made, yet it is easy to see how, by studying these, and by studying both the science and the art of feeding, we are able to arrive at many valuable results. We can thus quite confidently indicate what are the best and most economical foods in general, and for those engaged in any special departments of work.

Seeing what constituents are needed by the system to produce flesh, or heat and force, we note next to what extent these are found in some of the more valued foods.

8. The **fibrin**, **albumen**, **casein**, **gelatin**, and **gluten** are the chief **nitrogenous** foods.

Fibrin is found chiefly in butchers' meat and poultry, 19 to 22 per cent; in fish, 13 to 15 per cent.

Albumen is found in butchers' meat and poultry, 2 to 3 per cent; in fish, 4 to 5 per cent; in eggs, 15 to 18 per cent; and in ox-liver, 20 per cent.

Casein is found chiefly in milk, the proportion for that of cows being 4½ per cent.

Gelatin is contained in fish and butchers' meat, 6 to 7 per cent; in bones, 39 to 49 per cent; in isinglass, 70 to 93 per cent. The chemical composition of animal and vegetable **albuminates** is very similar, and they manifestly serve equal purposes in the body.

Of **gluten** there is in common turnips $\frac{1}{10}$ of one per cent; in cabbage, $\frac{4}{5}$ of one per cent; in red beets, $1\frac{1}{3}$ per cent; in potatoes, 3 to 4 per cent; in Indian-corn, dry peas, and rice, about $3\frac{1}{2}$ per cent; in barley, 6 per cent; in oats (Scotch), $8\frac{3}{4}$ per cent; in wheat (usual range), 11 to 15 per cent; in rye, 8 to 10 per cent; in beans, $10\frac{1}{3}$ per cent.

Fats are supplied as follows: Lard and drippings contain 98 to 99 per cent; suet and fresh butter, $87\frac{1}{2}$ per cent; dried bacon, $74\frac{1}{2}$ per cent; green bacon, $71\frac{1}{2}$ per cent; fresh mutton, 45 per cent; cocoa and chocolate, 42 per cent; fresh beef, $33\frac{1}{2}$ per cent; salted beef, $12\frac{3}{4}$ per cent; cheese, 28 per cent; eggs, 11 per cent; fresh herrings, 7 per cent; Indian-corn, $5\frac{1}{2}$ per cent; oatmeal, 5 per cent; new milk, $3\frac{1}{2}$ per cent; skim-milk, 2 per cent; buttermilk, $1\frac{1}{2}$ per cent; wheaten flour, 1 per cent; and even bread and rice, $\frac{3}{4}$ per cent. These percentages will be larger if the fat be in its ordinary and not dried state; the difference is in the water which the fat ordinarily contains.

Sugar and **starch** are the chief representatives of the carbohydrates or carbonaceous foods which are not fat, and are found mostly in cereal and vegetable foods.

Of **sugar** we have as follows: Rice, about 1 to 2 per cent; maize, $1\frac{1}{2}$ per cent; peas, 2 per cent; rye-meal and wheaten bread, $3\frac{1}{4}$ to $3\frac{1}{2}$ per cent; cows' milk, $4\frac{3}{6}$ per cent; oatmeal, 8 per cent; wheaten flour, from 6

to 8 per cent; beet-root, 5 to 10 per cent. Fruits vary from 10 to 20 per cent. Potatoes have about 2 per cent.

In **starches,** various kinds of potatoes vary from 12 to 24 per cent; beans, 34 to 36 per cent; wheaten bread, 53½ per cent; wheaten flour, 56½ to 72 per cent; oat-meal, 59 per cent; rye-meal, 61 per cent; barley-meal, 67 per cent; maize, 81 per cent; rice, 83 to 85 per cent.

Arrow-root, sago, and tapioca contain a still larger proportion of starch.

9. Remembering that the protein, albuminoids, or **nitrogenous** nutrients represent the flesh-forming and tissue-repairing foods, and the fats and carbohydrates the non-nitrogenous, **carbonaceous,** or heat and force producing foods, as nearly as distinctions can be drawn, the following tables of Prof. W. O. Atwater will give an idea of the proportions in ordinary foods as purchased.

They are worthy of careful notice, as an indication of relative values, and as showing how nearly the findings of experimental science correspond with our experience. We are also much helped in preparing dietaries, and in suiting foods to the varying requirements of the system.

The table of Bell which follows, showing the constituents of cereals, also gives a correct idea of relative values.

TABLE I.—Composition of Animal Foods.

Edible Portion. — Flesh, etc., freed from Bone, Shell, and other Refuse.

Kinds of Food-Materials. (*Italics* indicate European analysis, the rest are American.)	Water.	Total Nutrients.	Nutrients. Nitrogenous or (albuminoids).	Fats.	Carbo-hydrates.		Ash.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		Per ct.
MEATS. Fresh.							
Beef, side, well fattened	54.6	45.4	17.2	27.2	....		1.0
Beef, lean, nearly free from fat .	76.0	24.0	21.8	0.9	....		1.3
Beef, round,* rather lean . . .	66.7	33.3	23.0	9.0	....		1.3
Beef, sirloin,* rather fat	60.0	40.0	20.0	19.0	....		1.0
Beef, neck,* "second cut" . . .	64.5	35.5	19.9	14.5	....		1.1
Beef, liver	69.5	30.5	20.1	5.4	3.5		1.5
Beef, tongue	63.5	36.5	17.4	18.0	....		1 1
Beef, heart	56.5	43.5	16.3	26.2	....		1.0
Veal, lean	78.8	21.2	19.9	0.8	....		0.5
Veal, rather fat	72.3	27.7	18.9	7.5	....		1.3
Mutton, side, well fattened . .	45.9	54.1	14.7	38.7	....		0.7
Mutton, leg	61.8	38.2	18.3	19.0	....		0.9
Mutton, shoulder	58.6	41.4	18.1	22.4	....		6.9
Mutton, loin (chop)	49.3	50.7	15.0	35.0	....		0.7
MEATS.—Prepared.							
Dried Beef	58.6	41.4	30.3	4.4	....		6.7
Corned Beef, rather lean . . .	58.1	41.9	13.3	26.6	....		2.0
Smoked Ham	41.5	58.5	16.7	39.1	....		2.7
Pork, bacon, salted	10.0	90.0	3.0	80.5	....		6.5
FOWL.							
Chicken, rather lean	72.2	27.8	24.4	2.0	....		1.4
Turkey, medium fatness	66.2	33.8	23.8	8.7	....		1.3
Goose, fat	38.0	62.0	15.9	45.6	....		0.5
DAIRY PRODUCTS, EGGS, Etc.							
Cow's Milk	87.4	12.6	3.4	3.8	4.8		0.7
Cow's Milk, skimmed	90.7	9.3	3.1	0.7	4.8		0.7
Cow's Milk, buttermilk	90.3	9.7	4.1	0.9	4.0		0.7
Cow's Milk, whey	93.2	6.8	0.9	0.2	5.0		0.7
Cheese, whole milk	31.2	68.8	27.1	35.4	2.4		3.9
Cheese, skimmed milk	41.3	58.7	38.3	6.8	9.0		4.6
Butter	9.0	91.0	1.0	87.5	0.5		2.0
Hen's Eggs	73.1	26.9	13.4	11.8	0.7		1.0
FISH, Etc.							
Flounder, whole	84.2	15.8	13.8	0.7	....		1.3
Haddock, dressed	81.4	18 6	17.1	0.3	....		1.2
Bluefish, dressed	78.5	21.5	19.0	1.2	....		1.3
Cod, dressed	82.6	17.4	15.8	0.4	....		1.2
Whitefish, whole	69.8	30.2	22.1	6.5	....		1.6
Shad, whole	70.6	29.4	18.5	9.5	....		1.4
Mackerel, average, whole . . .	71.6	28.4	18.8	8.2	....		1.4
Salmon, whole	63.6	36.4	21.6	13.4	....		1.4
						Salt	
Salt Cod	53.8	26.1	21.7	0.3	....	20.1	4.1
Smoked Herring	34.5	53.8	36.4	15.8	....	11.7	1.6
Salt Mackerel	42.2	47.2	22.1	22.6	....	10.6	2.5
Oysters	87.2	12.8	6.0	1.2	3.6		2.0

TABLE II.—Constituents of Vegetable Foods.

KINDS OF FOODS.		Nutrients.				
	Water.	Nitrogenous (albuminoids).	Fats.	Carbo-hydrates, etc.	Wood fiber.	Mineral Matters.
FOODS.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Wheat-flour, average*	11.6	11.1	1.1	75.4	0.2	0.6
Wheat-flour, maximum*	13.5	13.5	2.0	78.5	1.2	1.5
Wheat-flour, minimum*	8.3	8.6	0.6	68.3	0.1	0.3
Graham-flour (wheat)	13.0	11.7	1.7	69.9	1.9	1.8
Cracked Wheat	10.4	11.9	1.7	74.6		1.4
Rye-flour	13.1	6.7	0.8	78.3	0.4	0.7
Pearled Barley	11.8	8.4	0.7	77.8	0.3	1.0
Buckwheat flour	13.5	6.5	1.3	77.3	0.3	1.1
Buckwheat "farina"	11.2	3.3	0.3	84.7	0.1	0.4
Buckwheat "groats"	10.6	4.8	0.6	83.1	0.3	0.6
Oatmeal	7.7	15.1	7.1	67.2	0.9	2.0
Maize-meal	14.5	9.1	3.8	69.2	0.8	1.6
Hominy	13.5	8.3	0.4	77.1	1.3	0.4
Rice	12.4	7.4	0.4	79.2	0.2	0.4
Beans	13.7	13.2	2.1	53.7	3.7	3.6
Peas	15.0	22.9	1.8	52.4	5.4	2.5
Potatoes	75.5	2.0	0.2	20.7	0.8	1.0
Sweet Potatoes	75.8	1.5	0.4	20.0	1.1	1.2
Turnips	91.2	1.0	0.2	6.0	0.9	0.7
Carrots	87.9	1.0	0.2	8.9	1.2	0.8
Cabbage	90.0	1.9	0.2	4.9	1.8	1.2
Cauliflower	90.4	2.5	0.4	5.0	0.9	0.8
Melons	95.2	1.1	0.6	1.4	1.1	0.6
Pumpkins	90.0	0.7	0.1	7.3	1.3	0.6
Apples	84.8	0.4	0.0	12.8	1.5	0.5
Pears	83.0	0.4	0.0	12.0	4.3	0.3
Starch	15.1	1.2	0.0	83.3	0.0	0.4
Cane-Sugar	2.2	0.3	0.0	96.7	0.0	0.8
Wheat-bread †	32.7	8.9	1.9	55.5		1.0
Graham-bread	34.2	9.5	1.4	53.3		1.6
Rye-bread	30.0	8.4	0.5	59.7		1.4
Soda Crackers	8.0	10.3	9.4	70.5		1.8
"Boston" Crackers	8.3	10.7	9.9	68.7		2.4
"Oyster" Crackers	3.9	12.3	4.8	76.5		2.5
Oatmeal Crackers	4.9	10.4	13.7	69.6		1.4
Pilot (bread) crackers	7.9	12.4	4.4	74.2		1.1
Macaroni	13.1	9.0	0.3	76.8		0.8

10. **Cereal Foods.** — The chief of these are wheat, maize, rye, oats, and rice. They are the seeds of various grasses, and are usually called **grains**. They are the most

* Of analyses of American flours.

† From flour of about average composition.

The analyses of foods in Roman letters are American, those of foods in *Italics* are European.

valuable of all food substances, because they contain so many of the constituents needed for life and health.

The following table of Bell gives the usual proportions.

TABLE I. — Constituents of Cereals.

Constituents.	Wheat. — Winter sown.	Wheat. — Spring sown.	Long-eared Barley.	English Oats.	Maize.	Rye.	Carolina Rice without husk.
Fat	1.48	1.56	1.03	14.5	3.58	1.43	.19
Starch	63.71	65.86	63.51	49.78	64.66	61.87	77.66
Sugar (as cane) .	2.57	2.24	1.34	2.36	1.94	4.30	.38
Albumen, etc. insoluble in alcohol	10.70	7.19	8.18	10.62	9.67	9.78	7.94
Other nitrogeneous matter, soluble in alcohol	4.83	4.40	3.28	4.05	4.60	5.09	1.40
Cellulose	3.03	2.93	7.28	13.53	1.86	3.23	Traces
Mineral matter . .	1.60	1.74	2.32	2.66	1.35	1.85	.28
Moisture	12.08	14.08	13.06	11.86	12.34	12.45	12.15
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The ash constituents are about as follows: —

TABLE II. — Constituents of the Ash of Cereals.

Constituents.		Wheat. — Golden Drop.	Barley.	Oats. — (Middlesex).	Rye.	Maize. — (American).	Rice without husk. (Carolina).
Total ash on dry grain .		1.81	2.66	3.01	2.11	1.54	.31
Potash	K_2O	30.07	12.74	9.34	20.42	26.01	17.71
Soda	Na_2O	.66	4.03	—	—	.91	—
Sodium chloride . .	$NaCl$	3.05	.31	1.03	2.78	2.13	3.24
Magnesia	MgO	11.39	7.59	7.75	9.23	18.73	7.86
Lime	CaO	5.17	3.45	4.22	1.89	1.82	2.62
Oxide of iron . . .	FeO	.19	.34	.36	1.25	.52	.60
Alumina	Al_2O_3	Trace	2.28	—	.11	—	—
Oxide of manganese	Mn_2O_3	Trace	Trace	Trace	Trace	Trace	—
Sulphuric anhydride	SO_3	3.18	1.44	3.10	1.29	1.62	.87
Phosphoric anhydride	P_2O_5	45.50	39.11	32.09	48.03	47.45	65.36
Silica	SiO	.79	24.70	39.56	10.43	.81	1.74
Sand		—	4.01	2.55	4.57	—	—
Total		100.00	100.00	100.00	100.00	100.00	100.00

11. The following gives an idea of the proportions in usual wheat-flour.

TABLE III.—Constituents of Flour.

CONSTITUENTS.	Household	Best Household.	Best Whites.
Starch and Dextrine	69.04	71.05	70.33
Cellulose	.52	.70	.77
Sugar corresponding to cane sugar.	.71	.64	.68
Albuminoids and other nitrogenous matter insoluble in alcohol	9.36	7.94	9.40
Nitrogenous matter soluble in alcohol	6.83	5.05	4.20
Fat	1.06	1.22	1.08
Mineral matter	.67	.73	.58
Water	11.81	12.67	12.96
Total	100.00	100.00	100.00

A part of the nitrogenous matter is represented by crude **gluten,** which can be separated by kneading the flour in a little water, and then pouring a stream of water upon it while the kneading is continued, so as to wash out the starch. It also carries with it soluble nitrogenous principles, and albumen. Ordinary wheat-flour contains in all from 85 to 95 per cent of nutritive material.

Bread can be prepared either from grains from which the husk or covering is separated, as in the usual white bread, or from flour in which this is retained, generally known as **brown-bread.** There has been much discussion as to their comparative nutritive properties. It is true that in the husk or covering there is more of the fat and of phosphates or bone-making material, but a very thin removal of the husk can take place without removing much of this. If all is retained, rough particles of the husk may produce irritating effects, and

interfere with assimilation. The amount of waste is at least double that of white flour bread. Brown-bread is often falsified, bran and a little molasses being stirred into second-rate dark flour.

Whole wheat is sometimes run between rollers, and so deprived of any roughness which the husk might give it. There can be no doubt that if bread could be prepared with less removal of the covering of the grain, it would be a little more nutritious.

Average wheat bread has 28.5 per cent of carbon, and 1.27 per cent of nitrogen, and hence one pound will contain 1996 grains of carbon and 89 grains of nitrogen. It is, therefore, at usual prices, a good standard of nutritive, economical food. One pound of Scotch oatmeal has 2800 grains of carbon and 140 of nitrogen, and is therefore not so economical as wheat flour.

12. **Indian-corn** is a nutritious and economical food, and deserves, as such, far more attention than it receives. Its nutritive value is, in carbon, the same as wheat flour, and its nineteen grains less of nitrogen is compensated for by a considerable quantity of free hydrogen, which is found in the fat, in which the grain is somewhat rich. It depends for its digestibility and for its relish more on **cooking** than does the wheat flour. It requires long boiling, and to be carefully stirred into hot water while being prepared. If thus allowed to boil for an hour or more, and made so as not to become too thick when cold, it can be cut into slices and used for frying, and thus form both a nutritious and savory dish.

13. **Milk** is to be regarded as a leading food, because it contains each and all of the food constituents in the

best proportions. Each pint of good milk has 546 grains of carbon, and 43¾ grains of nitrogen, with all needed salts. The two leading constituents are the casein, which makes cheese, and the fat, which makes butter. It is better warmed, but not boiled, when taken with meals, as this mingles the oil and casein more fully with the milk, if it has been kept standing. **Skim-milk** has only lost the most of the oil of the milk, and is therefore inferior only in this one ingredient. At one cent per pint, Edward Smith, a high English authority, says of it, that there is no animal food which is cheaper. When used in cooking, a little added suet supplies the place of the cream. **Buttermilk** is equally valuable as a food, except when it is churned from very sour milk, or has become cheesy by age. Even in this state it is largely eaten in Ireland, and it is found that the amount of food derived from it in this condition is more than half of that of skimmed milk.

Smith, in his dietary, insists that skim-milk, buttermilk, and even the whey of milk, have such value as foods, that, unless there is very unusual cheapness of other articles, they are most important additions to human foods.

The whey, although having lost its fat and cheese, has sugar of milk and lactic acid, and is not only nutritive, but is often an aid to digestion.

Cheese, if made of milk only, is the representative of the casein of the milk, with some fat, and is a cheap food. While a little may aid digestion, enough for a meal is only partially digested, so that it is doubtful if more than two ounces at a time is available.

14. **Meat** is a form of food which, when rightly prepared, is easily transformed into our own flesh or tissue. In its ultimate composition it does not differ much from flour, and, in its albuminates, but little from some vegetables. There is much more water in flesh than in flour, although with this extracted flesh is a very concentrated food. Of all flesh, **beef** and **mutton** are the best regular foods. The evil effects which are so generally claimed to follow the use of pork and veal, says Smith, "have not, I believe, any connection with the composition of those meats, but depend upon the imperfect way in which they are masticated and prepared for the process of digestion. The **lean flesh** of pork is hard, whilst the fibers of the flesh of veal are held loosely together, so that in the former case the teeth separate the fibers with difficulty, and in the latter the fibers elude the grinding process of mastication; and, in both cases, the meat is swallowed in masses too large for the ready action of the gastric juice." So much depends upon right cooking and right mastication. Inferior cuts of meat often differ in value only because of the absence of fat between the layers of fiber, and their less juiciness and consequently less flavor.

Coarseness of fiber interferes with mastication, and thereby with digestion.

In the English market, with every piece of flesh sold a small piece of bone is added. **Bones** broken and boiled for six or eight hours add much nutrition to broths and soups, because of the alkaline and other salts which they contain.

Pork or bacon, although so often talked against, is a very important food. Bacon differs from beef and

mutton only in the two facts, that the proportion of fat to lean is much greater, and that it has undergone the process of salting, and, being dry, it possesses a larger amount of nutriment to a given weight than when the flesh was fresh. It therefore supplies more carbon, and thereby diminishes the necessity of bread; but it offers less nitrogen, and thereby renders the demand for milk and other highly nitrogenous food greater. In point of practical economy, bacon exceeds fresh meat. It is true of it, as of all salted meats, that the salt draws out the juices of the meat, and at the same time hardens the fiber and diminishes or takes away its digestibility. The fat of the pork, however, is not toughened by it so as to interfere with digestion.

As **pork** can now be preserved without so large an addition of salt, and as thorough cooking overcomes objections grounded on the presence of parasites, which also exist in other foods, we believe that great care should be used to secure a large produce of this food, and a proper condition of it before salting.

15. **Eggs** are very valuable as adjuncts to other food, since they consist chiefly of nitrogenous matter, but being deficient in carbonaceous material, they must be eaten with bread or other carbonaceous food.

Fish may be compared with butchers' meat by reference to the tables already quoted. In the flesh of most fish, the nutritive material is largely **protein**. If they can be procured fresh, and properly cooked, they are a cheap and valuable food. Those not rich in oil need the addition of fat in frying or as dressing, but the food is highly available. Salting makes

the same variation of value as is made by the salting process for meats. But if the fiber is not tough, and the overplus of salt is removed, salt fish is both appetizing and economical. It needs thorough chewing.

16. **Beans** deserve a very high rank among the dry farinaceous foods. They are far more palatable and available than the dry peas which are used largely abroad. The common bean, the kidney or haricot bean and the lima-bean, are all very valuable, the economy depending on their comparative price. The nutritive value of beans is higher than that of all other vegetables, since they somewhat exceed that of wheaten flour in carbon, and have more than double the amount of nitrogen. Bean soup, made after the beans have had proper soaking, and with no undue amount of pork, or baked beans, or beans dried after being cooked and ground, and used as a kind of flour for admixture in puddings, make a most valuable and economical dish. Peas have similar qualities to beans, but not in the same degree.

Potatoes, as to their value and economy, need very careful attention from all householders. They are capable of furnishing a most valuable addition to breadstuffs, and oils and meat; but very much depends on the quality of the potato and the modes of preparation.

In each pound of good peeled potatoes there are 770 grains of carbon and 24 grains of nitrogen. As they are below the value of bread, their economy will depend on the relative price.

A potato which, after cooking, cuts like soap, or is

eaten cold, is not easily digested, and yields up its nutriment tardily. It is most economical to roast them, or to boil them with the skins on, in which case they should be eaten hot. Potatoes contain some valuable potash salts which are mostly lost in boiling without skins, but are retained in baking and stewing.

17. **Green Vegetables.** — Cabbage, turnips, carrots, parsnips, and onions contain from 85 to 92 per cent of water before cooking; and therefore their amount of nutrients is small in proportion to bulk.

Parsnips rank next to potatoes in nutriment, and possess 6 per cent of carbon and 0.22 per cent of nitrogen.

Carrots take the next place, and offer 5.5 per cent of carbon and 0.20 per cent of nitrogen.

The Swedish **turnip** and the **onion** contain 4.5 per cent of carbon and 0.22 of nitrogen. The common turnip ranks a little lower.

Cabbage, although so much used, ranks inferior to these in the nutriment which a given weight contains. For practical purposes, **all succulent** vegetables may be classed together, and one pound of each computed to contain 420 grains of carbon and 14 grains of nitrogen.

18. It is to be borne in mind that most of these vegetables have **gluten,** as a nitrogenous food in an available form, which is to be taken into account in their absolute value and in their comparative rating. The amount of this found in some of them is as follows: —

Beans (farinaceous vegetable) . . .	$10\frac{1}{3}$ per cent.
Cabbage	8 " "
Potatoes	3 to 6 " "
Red beets	$1\frac{1}{3}$ " "

Poor **wheat** has as low as 9 per cent, and barley and Scotch oats from 6 to 7 per cent.

Potash and soda and phosphorus are found combined in most vegetables; and iron is met with in carrots, potatoes, cabbage, tomatoes, and even in cucumbers.

It is plain that these vegetables are to be rated at rather more than their food-values because of their juices as appetizers. Parsnips, carrots, and beets possess much sugar in their valuable juices, and a considerable amount of other elements of nutrition. The same can be said of **onions**, which, like cabbage, seem to draw a large portion of their food from the atmosphere, and to have something of the tonic effect of pure air. The essential oil of the onion is a stimulant to digestion. **Cabbage** resists certain kinds of fermentation. The **tomato**, half fruit and half vegetable, besides its general value, is of great service as an appetizing sauce. Tomatoes also, besides a trace of iron, contain an acid, like that of the apple. All these vegetables are available as changes from the regular diet, and, like the fruits, as having juices whose full advantages are to be learned only by close watching of effects.

It is true of all vegetables that they are most digestible when well-cooked, without grease, and seasoned and oiled, if need be, afterward.

19. **Sugars.**—These, as available to man, are found all ready in cereals, vegetables, and in most fruits, and are derived, in different forms, from the sugar-cane, the sugar-maple, from beets, and are in the crystallized form of cane-sugar. Glucose is another form of sugar of less sweetening and food qualities. It is found in honey, and

obtained from potatoes, Indian-corn, etc. There is not much of it in vegetable juices. Molasses has much of it not derived direct from the sugar-cane, but in process of heating a transformation takes place. As a rule, artificial sugars are not economical as a part of diet. Nature converts the starch of many of our foods, such as bread, potatoes, etc., into sugar, and avails itself of the natural supply contained in milk, fruits, etc., so that in a perfect diet, for perfect health, much more sugar is not needed.

Sugar has no nitrogen, and contains 2800 grains of carbon to a pound. Smith speaks of it thus: "**Sugar** is the first article to be cut off or discarded in times of pressure, and in districts where milk is very abundant and cheap, its ordinary use is almost unknown. . . . It is, however, a very valuable food, since it is most rapidly digested, and supplies heat-forming materials to the body. When, however, it is compared with wheaten flour it is a very dear food, since three to four times more carbon will be obtained for one pennyworth of flour, besides the nitrogen, none of which is found in sugar. It has also been proved that even its fattening properties, when it is supplied in excess of the quantity which the daily wants of the body require to produce heat, are not greater than that of starch as found in the cheapest grains. . . . Whilst it is a good food, it is not an economical one." Children do not derive quite as much sugar from the starches as do adults, and therefore it is a little more needed by them. It is best eaten in the form of a pure syrup, with bread.

20. **Cookery of Foods.** — In comparing the constituents of the human body and of foods, we have seen that they are so much the same as to show that our

demand for, or our acceptance of foods, depends upon the fact that they have in store just what is the make-up of the human system. Where, as in the case of sugar and starch, they do not reappear in the body, we know just how they have been converted into heat and force. They do not actually appear in substance and deposit in the body only because they are so energetically converted into power in the process of digestion.

But we must not only find these materials in foods, but find them in such a state as that they can be appropriated. The foods, as stored in the animal or vegetable, may not be in such a state as to be appropriated by ordinary digestion, or the digestive apparatus may be incapable of doing its work of assimilation when they are rightly furnished. In either case there will be failure of nutrition. Just now we have to do with that failure which may occur from the **condition** of the food. It is the great design of cookery to place food in such a soluble and digestible state as will render it most available to the digestive organs. In doing this, it is true, we have some regard to flavors whose power over appetite and digestion we cannot chemically analyze. But the chief point is to secure that **tenderness of fiber,** and that condition of flesh-forming and heat-producing material contained in them, which will be most readily digested and absorbed. This means very different treatment for different substances.

21. Thus even **cooked water** is in many respects different from unboiled water. The boiling expels the air and other gases always occupying the interspaces between the particles of natural water. The water contains in solution some mineral constituent, as lime, which is

precipitated by boiling. Organic impurities are by this process driven off in the form of gases. We now know that minute forms of life, both animal and vegetable, exist even in pure water, and in much greater quantities in impure water, and that these are destroyed by boiling. This general fact does not make it necessary that water should always be boiled, but when we are suspicious of a water-supply it is well to boil the water. If it is aerated afterward, by pouring it from one vessel to another, we secure the advantage of aerated water without the risk of impurities. It is true also that **tepid water,** taken at the time of meals, agrees better with the digestion of some persons than does cold water. It is claimed that the Chinese would suffer much more than they do from the filthiness of some of their cities and dwellings, were it not that the ordinary drink of the people is boiled water flavored by an infusion of tea leaves.

22. There are some articles that are made less digestible, or their contents less available, by cookery. Thus a fresh **egg,** beaten raw, with a little salt and sugar added, is more digestible than any form in which it can be cooked.

The egg, both white and yolk, is chiefly composed of albumen, the yolk having added to it a peculiar oil and some coloring matter.

If we immerse an egg in boiling water, and keep it boiling for about three minutes, we convert the white into a tough, hard, and indigestible mass. The yolk has scarcely been warmed. The outer albumen is hard, although we call it a soft-boiled egg. The reason is that we have kept up a cooking temperature

of 212° F., when only 160° F. is needed to coagulate albumen. If the water is brought to the boiling-point and removed from the fire, and the egg at once dropped in so as to be covered by the hot water, and allowed to remain in the covered sauce-pan for from ten to fifteen minutes, it will be a soft-boiled egg, with the albumen, all through, in a **flaky,** instead of a **hardened** state, and so much more digestible. This, without further details, serves as an example of the relation of the cookery of foods to the amount of food-value actually derived from any given article. It well illustrates what proper cookery can do to preserve or make palatable a most valuable food, and on the other hand to diminish or almost destroy its value.

23. Since albumen exists in flesh mostly in a juicy form, this fact as to eggs has an important bearing on the **cookery** of all **meats.**

If we desire to fully extract the juices of the meat, so as to make **soup,** since albumen is soluble in cold water gradually raised to a heat below 160° F., we put the meat in cool or lukewarm water and keep it simmering for a considerable time at a temperature below this point, until its soluble compounds have passed into the soup. Then a gentle squeezing of the meat will still add more to the soup.

If, on the other hand, we desire that the nutrient strength of the meat be retained in the meat itself, we pursue exactly the opposite course. The joint is plunged into boiling water, so that the albumen may harden on its surface. If kept constantly boiling, there will again be too much hardening of the albumen in the interior; so after about five minutes of boiling,

the vessel should be set aside where the water will retain a temperature of about 180° F. Of course it will take longer thus to get the boiled leg of mutton thoroughly done, but the difference both in flavor and in nutrient qualities will repay for the trouble. Even the addition of salt has a special purpose, since it helps to coagulate the outside albumen, raises the boiling-point of the water, and by increasing the density of the water, retards the oozing out of the juices.

When meat is **stewed**, the intent is to separate the juices from the meat and transfer them into the other materials of which the stew is composed. Here, again, as we do not wish to confine the juices, **simmering**, and not boiling, is the process. In **roasted** meat, on the other hand, the design is to retain the juices in the meat, and to concentrate them by evaporating some of the water mingled with them, and then to give to them additional flavor by a browning of the surface.

These examples will suffice to illustrate how a piece of meat may, by its mode of cookery, be deprived of its nutritive qualities, or have them transferred quite fully as in soup, or partly as in stewing, or have them retained and made more digestible by the tendering of the fiber and the concentration of the juices, as in boiling or roasting.

24. Grains, as used in various forms, are greatly affected by cookery.

Rice, oftenest of, all is used without any grinding or kneading preparation. It is a grain that, when well prepared, is nearly all assimilated, and in the climates where not much oil is needed, must ever be the leading food. If put in cold water, and over a

good fire, it is cooked by the time the water reaches the boiling-point. As soon as it is done, it should be rapidly drained, so as to rob every grain of moisture. It is true that it may be rendered palatable in other ways, but this is the kind of cooking that will allow the greatest amount of it to be assimilated.

Oatmeal and **maize** are the other two grains which, after grinding, are used without kneading or fermentation by yeast.

In cooking so simple a dish as oatmeal porridge, the difference between cooking it rapidly to the boiling-point in a few minutes, and simmering it gently for nearly an hour, will determine its ease of digestion, and the amount of it which will be assimilated. The same is true as to mush made from maize or Indian-corn.

Bread is made from the flour or meal of grain by moistening it with water and mingling it with yeast, or gaseous matters, in order by fermentation or aeration to make it light, and baking it. As bread has in it water, albuminoids, and carbohydrates it undergoes important changes, which, if rightly conducted, aid in its assimilation.

While the albuminoids and nitrogenous matters are made less soluble, they are not made indigestible. The starch granules are broken up and changed into sugar and **dextrine,** both of which are more digestible. When well masticated, the bread of fine wheaten flour is more digestible than most grain foods.

25. The chief modes of preparing grains for bread are as follows: —

(*a*) Unleavened bread, such as the **corn-bread** of

America, or the **oat-cakes** and bannocks of Scotland, is made into a paste with water, salt being pretty freely added, and raised by quick heat.

(*b*) Leavened or fermented bread is made by using leaven or yeast, and thus causing fermentation, or rising and lightness. Thorough kneading diffuses the leaven, and also has to do with facilitating the chemical changes which take place in the mass. In this process, and in baking, the starch granules are closely combined with the gluten, and on the outer surface the starch is converted into dextrine and caromel, — forms of sugar. The loaf or roll is so made more easy of mastication and digestion.

The difference between the digestibility of well-prepared hot bread and of cold bread is not so much in their composition as in the fact that the hot bread is more **sticky**, or is more apt to be swallowed without sufficient **chewing**.

(*c*) Another form of raised bread is prepared by mechanical means instead of yeast, and is known as **aerated** bread. Water is charged with carbonic acid gas, and this is so brought into a closed space, partly filled with flour, and so mingled with it as to cause lightness, by the air-diffusion and artificial kneading. A quick baking, in a proper oven, secures a light bread through this **mechanical** method.

(*d*) Much bread in the form of hot bread or **biscuit** is made by using bicarbonate of soda and cream of tartar, or hydrochloric acid, or by means of bicarbonate of soda and the acid phosphates of lime and potash. These are mingled through the flour, and then the heat liberates the carbonic acid gas in the

process of baking, and so secures lightness. The various baking-powders and self-raising flours depend on this method. It cannot be said that this method is injurious, but by reason of impurities in commercial chemicals, or the effect of certain of these impurities on some digestive organs, they are not so uniformly reliable as the usual yeast-raising method.

26. **Vegetables.** — In the cookery of vegetables, as the main point is **tenderness,** and as the albuminoids are a subsidiary part, the boiling cannot be kept up too constantly to the time when they are just done. The water is to be kept boiling from the moment the vegetables are put in. They are to be kept pressed beneath the water, so as to cook equally, and at the moment they have become **tender** must be taken out and dried if necessary. It is true that vegetables lose somewhat in valuable salts and in other ingredients in cooking, but this is the least of the evils, since it is necessary to soften the fiber of leguminous plants.

The **water** in which peas, beans, asparagus, etc., are boiled is often used as a stock for soups, because of its flavors and slight nutrient qualities.

The tables before quoted show the comparative value of these vegetables as thus secured by cookery.

27. This brief outline of **foods,** and of the **cookery of foods,** will suffice to direct attention to the identity of materials found outside of the body with those of which the body is composed. While we are not able to explain the marvellous combination by which mental as well as physical power is elaborated, we are able to obtain most valuable indications as to what foods are to be chosen, how they are to be varied, and how they

are to be prepared. Chemistry and the results of actual use now enable us to adapt foods to particular conditions, so as to secure more flesh or more vigor. It is just as practicable for the individual to inquire how to feed so as to get the best health, and the best power for work or for usefulness, as it is for the engineer to inquire what kind of fuel will give the most steam, and how this steam can be utilized so as to secure the greatest amount of force.

The person who early comes to a proper consideration of these forces, their origin and the mode of their utilization, has made a very important step forward in education. Too many learn the lesson too late to make it wholly available. Each **student** and each **worker,** in any department must find out the indications in his own case,—what is desirable and what undesirable, what agrees and what disagrees, how food and sleep and exercise are to be adjusted to each other, and then acquire that poise, that self-control, that **behavior,** or having the being in possession, which will enable him to apply this knowledge in the daily business of living according to the general laws of health, and according to those individual modifications which his own constitution, capabilities, surrounding, and his own kind of labor require. Our knowledge of the **hygiene of digestion** and assimilation, and of foods and their preparation, is now such as to enable us to greatly conserve the health and physical education of the people.

CHAPTER XIII.

DRINKS AND CONDIMENTS.

THE chief **drinks** of mankind are water, milk, tea, coffee, cocoa, and fermented or distilled liquors. The need for any fluid arises from the fact that water is a conveyancer or medium of exchange for the various processes of nutrition, and for the removal of the secretions and excretions of the system. In one case, that of **milk**, it is the necessary vehicle for the food of mankind before the chewing apparatus is furnished. In other cases, it may or may not be used as the vehicle for various aliments, juices, or flavors of which it becomes the carrier. It has already been noted that the **juices** of grains, vegetables, meats, and fruits are a part of the natural water supply, as well as that which is furnished from the sky or in the earth as pure water.

2. **Tea, Coffee, and Cocoa.** — These, although needing a somewhat individual study, are so allied to each other as to justify their consideration side by side.

There is one organic constituent or alkaloid that is common to them all, and upon which, more than on any other ingredient, the call for or habit of their use depends. This essential **alkaloid**, as found in tea, is called theine; in coffee, caffein; and in cocoa, theobromine. The chemical formula given for the first two is $C_8H_{10}N_4O_2$ and for the theobromine $C_7H_8N_4O_2$. The theine-like alkaloid, found in cocoa and called

theobromine, is so slight a variation from the other two that these three, as to their stimulating alkaloids, are spoken of generally as identical. Their form of combination gives some variation as to their effects and as to the mode of treatment in order to secure it. Thus the theine in tea is in combination with tannin, and this fact must be regarded. Coffee is modified by its essential oil, and by the caramel developed in roasting. Carbon, hydrogen, nitrogen, and oxygen are found in each. They are all rich in nitrogen, tea containing about 29 per cent. While tea contains little or no available oil or fat, coffee has from 11 to 14 per cent, and cocoa contains from 47 to 53 per cent. In tea there is little or no sugar, or material for it. In coffee, the starch, sugar, dextrine, and vegetable acids amount to from 15 to 16 per cent. In cocoa there is from 4 to 8 per cent of starch, convertible into sugar.

Roasted coffee has 1½ per cent of albumen, but tea and cocoa not enough in the soluble form to be appreciated.

As to the other nutrients, and the salts, they do not need comparison. While they have minute quantities of usual nutrients, in neither would the form nor the cheapness lead to their use for these. Sugar and milk, and their warmth, add much to their alimentary qualities.

3. It is the peculiar effect of the **alkaloid**, or essential principle of each, and their **aroma**, that inclines us to their use. Experiments with these, as separated have somewhat aided in our estimation of them. Each has a stimulating and restorative action on the nervous system, which is no doubt a little aided by the warmth.

In addition to the purifying effect of **boiling**, all these drinks have slight **antiseptic** qualities. This is especially true of the caramel of roasted coffee. **Tea** increases the action of the skin and the amount of water secreted by the kidneys. **Coffee** is more stimulating to the nervous system, in part perhaps due to its essential oil. The refreshing effect of tea is more lasting. **Caffeine** given in full doses to animals will produce trembling and stiffness of the muscles. No depression follows the use of either.

4. The effect of tea and coffee is somewhat different upon different persons, and is to no small degree to be learned by close observation. As they are not to be accepted as **foods**, in the usual sense of the word, we are to watch closely their effects, and to be governed by these, in judging of the propriety or extent of their use in individual cases. It is true of all stimulants and nervines, that the effect is somewhat modified by their being taken apart from food and into an empty stomach. They are generally best taken near or at the time of eating. **Tea**, because of the tannin it contains, is sometimes used as an astringent. Its action in this regard is not so great as in usual quantities to interfere with digestion. The **casein** of milk combines with the tannic acid, and, while diminishing the amount in taste, makes it more insoluble. When taken frequently and in large quantities, it no doubt enfeebles the digestion. This is one reason why cream is much better for tea than milk.

The **young**, as a rule, are better off without tea and coffee, unless they are taken in such small quantities as to be merely a flavor to some warm fluid. For some, they

are better at meals than cold water. Very hot water, made cool enough to drink by the addition of milk, and sweetened with sugar, is a good drink, and will not be found insipid to those who become accustomed to its use.

5. The objections made to tea and coffee do not apply to cocoa. The large amount of fat and of albuminoid or nitrogenous substance contained in cocoa gives to it a real food value. The starch it contains is converted into dextrine in the roasting of the beans or seeds. After roasting, the beans are passed through a machine which loosens their husks or outer coat. These being separated, the nibs or inner pieces of the bean are left. It is furnished in the market in this form, or more generally in a powder or paste, as ground cocoa and chocolate. They can be had pure, although there are many adulterations; that with **fat** and **starch** is among the most objectionable. The amount of natural oil is an objection to many. Much of it is now removed, and the cocoa-butter, as it is called, is used for other purposes. Preparations of cocoa and chocolate, from which the oil has been removed, are to be preferred. If nicely prepared with hot water, milk, and sugar, they may, with much advantage, be brought into more general use.

Our drinks have so much to do with health, and with that vital force we need for study or other work, that it is well to secure early in life definite choices in judgment and habits as to their use. While there are many who make too free a use both of tea and coffee, their moderate use rests upon entirely a different evidence and defence from that attempted for some other drinks.

6. **Alcoholic Beverages.** — Every person needs to know the relation that fluids containing alcohol bear to **foods**, and to individual and public **health.** Their effect on **mind** and **morals** cannot be overlooked, since these have to do with the welfare of the body. If they tend to the formation of **habits** which seriously affect health, or if they in any wise weaken that power of self-restraint or self-control which is at the basis of both health and character, the young need to be informed and impressed in time with the peril their use involves. However much spirituous liquors differ among themselves, as they do in many respects, they all depend for their use as beverages upon the **alcohol** they contain. There is a slight food-value in some of them, because of the fruits or grains from which they are derived, and of the sugar, salts, and oils they may contain. But neither on the ground of value or cheapness as a food would they ever be sought. Alcohol is a neutral compound of carbon, hydrogen, and oxygen, which, by the action of acids, form ethers. The most common variety of it is spirit of wine or ethylic alcohol (CH_4O). In its common definition, it is that inflammable, volatile, spirituous liquid which is the intoxicating principle in spirit, wines, and beers.

7. Liquors containing alcohol are generally spoken of under two classes. These are the **fermented** liquors, as wine, beer, etc., and **distilled** liquors, as brandy, whisky, rum, etc. **Fermented** liquors are said to be **fortified** when some distilled liquor is added thereto, either to preserve them or to make them more intoxicating. This is very frequently done.

Wines have various acids, glycerine, and a little albu-

minous substance. **Beer** contains, besides its alcohol, carbonic acid, volatile and fixed oils, malt extract, with a little starch, sugar, and albuminous substance, hop, resin, or other added bitters, and various salts. Pure **vinegar** is a better **acid** for health, when needed, than any of those from wines or beers.

Brandy is a spirit derived from the distillation of wine, or is made artificially by adding various substances to proof spirit. **Rum** is distilled from fermented molasses or inferior kinds of sugar-cane. **Whisky** is a spirit most frequently made from grains, as corn, rye, etc. It is also made from vegetables and fruits. **Gin** is a spirit made by diluting proof spirit and flavoring it with various substances. Any or all of these can be made artificially nearly like the distillation, so that they are not to be rated as necessarily falsifications.[1]

There are also many imitations and fraudulent preparations. Names do not represent distinct vintages or distillations so often as they represent the skillful combinations of various dealers.

8. It can be said of all alcoholic liquors, that there is nothing in them so desirable as to make it worth while to use them unless it can be shown that the **alcohol** is needed. When we come to study the relation of alcohol to **foods**, first of all we are impressed by the fact that it is **not found in nature**, as are such foods as are essential for the maintenance of life and health. No analysis of foods ever finds it present in them as an article to be taken into the human system. If it had any such food value as was once claimed for it,

[1] See Blythe's Manual of Practical Chemistry, and Prescott "On the Chemical Examination of Alcoholic Liquor."

this omission would have been a most surprising one. When we turn to the physiology of digestion, and of the appropriation of foods in the system, we find nothing whatever to indicate that it was ever intended to be used by mankind as a food. Every advance in chemistry, and in the knowledge of the relations of food to human force and vitality, has been an advance away from the recognition of alcohol. Such authorities as Liebig, Moleschott, Pettenkofer, Voit, König, Beneké, Meinert, Payen, Frankland, Playfair, Lewes, Smith, Parkes, Prescott, Nichols, and Atwater give it no place in any standard daily rations.

9. Before chemistry assigned alcohol its proper place, experience had classed it among the **toxics.** Persons affected by it were not said to be **fed overmuch,** but to be **intoxicated. Toxic** is the Greek word for poison. We can turn to no book to-day, in chemistry or hygiene, and find it treated among the articles of food. If we have regard to the convenient division of nitrogenized or flesh-forming foods, we soon find that it has no **nitrogen,** and therefore cannot be arrayed in this class. If we look for it among the heat-producing foods, we find that it does not respond to the laws of animal combustion, either by producing **force** or increasing **heat.** Notwithstanding the sensation of heat produced by its contact with the digestive track, or from other causes, the thermometer and other tests show that it produces a slight reduction of temperature.

In common with opium, chloral, hasheesh, and some other stimulants, narcotics, or nervines, alcohol has some temporary action where there has been a breach

of natural law by which the system has been thrown into an abnormal condition. By such momentary effect these steal their way into recognition so as to have been called **deceptive foods**. They create a habit which is interpreted by the willing subject into a demand.

10. As a rule, the serious fact in reference to alcohol is that it **interferes with nutrition.** It not only lacks food value of its own, but it detracts from the value of real foods. It so affects the organs which have to do with the assimilation and distribution of food, that they are incapacitated for or are disturbed in the performance of their functions.

Experience has preceded **science** in crossing it from daily rations. This is the more significant, because the tables of food intended for soldiers, for sailors, for those in institutions, and for invalids, have been studied out by the very highest authorities, and have been tested by the most exact experience. It has been while in search after the best methods for getting the most intense **force** and power of **endurance** out of men in national service by sea and by land, that this evil spirit has been cast out. All other considerations have been thrust aside, and on this **material basis alcohol** has been retired from service. Where continuous power is desired for efficient use it has no place. In **training** for athletic sports or manual contests, it is rigidly excluded from the **dietary** even of those who have been accustomed to its use. It utterly fails to be a **nutrient,** or to answer the purposes for which foods are intended. In view of its appalling effects on society, even if it were a food it would need to be proven to be a **necessary food.** It accomplishes so

much injury to human health and life, that it ought to be prohibited from use. Even **rye** would be prohibited from use if no rye could be had which had not ergot in it, and if the disease known as **ergotism** came to be prevalent among the people, as is disease from alcohol.

11. As to the **effect** of its use upon **human health** and **vigor,** so fearful is the record, and so repeated and almost universal is the testimony, that we need not to report much of it here. Perhaps the most convincing recent evidence is that of the returns of vital statistics of the Registrar-General for England and Wales, for the last ten years from 1870 to 1880 inclusive. These are contained in the supplement of the Forty-fifth Annual Report (1885), in which are tabulated the facts as to two million six hundred and seventy-nine thousand four hundred and sixteen deaths. These are the results of unimpassioned figures, gathered outside of the records of Reform Societies.

"The mortality of men who are directly concerned in the liquor-trade, as brewers, innkeepers, publicans, inn and hotel servants, and maltsters, is appalling. The comparative mortality figures are as follows, 1,000 being used as a standard: Brewers, 1,361; all dealers in spirits, wines, or beer, 1,521; inn and hotel servants, 2,205. For maltsters, who are only concerned with the materials and not with the liquor itself, the figure is 830."

The report proceeds as follows:—

"It is well, whenever the opportunity offers itself, to test the accuracy of our death-rates by comparison with data derived from independent sources, and in the case of the

innkeepers and publicans such comparison is possible. By the experience of the Scottish Amicable Life Assurance Society (1826–1876), the mortality of males occupied in this business was 68 per cent in excess of the actuaries' or healthy male-table, and 49 per cent in excess of the English life-table. This result tallies very closely with figures in our table, where it appears that the mortality of the innkeepers and publicans is 52 per cent above the present mortality of all males.

12. "That this terrible mortality is attributable to drink might be safely assumed *a priori*, but the figures render it incontestable. The mortality attributed to alcoholism itself is far higher for innkeepers and publicans than for any other industry, and more than five times as high as the average; that for brewers falls far short of this, but nevertheless is the next highest to that of innkeepers, with the single exception of cabmen. Under the heading '*liver diseases*' the mortality of innkeepers is no less than six times as high as the average, and more than twice as high as that of brewers, and of butchers, who come next in order in this respect to innkeepers. . . . There are, in short, no organs apparently that are not more or less seriously damaged by the excessive use of alcoholic drinks, though the liver appears to suffer the most.

13. "It may also be worth noting that a comparison between Mr. Neison's figures and our own comparative mortality figures shows that a large proportion of the innkeepers and publicans, and of the brewers, must be of **temperate** habits; for whereas the comparative mortality figure of innkeepers in our table is 1,521, and that of brewers is 1,361, that for recognized intemperate persons, according to Mr. Neison's data, would be 3,240."

Their desire for profitable business often helps to restrain innkeepers from drunkenness. While the tables

show the greater evil of distilled liquors, the wine and beer death-rate is enormous.

Such is the excess of death-rate among those whose business interests help to restrain them from drunkenness.

At the same standard, the mortality figure for clergymen shows the contrast of 556; for gardeners, 599; for farmers, 631; and for agricultural laborers, 701.

14. In addition, the statisticians say that the excessive mortality in many other callings, as that of cabmen, etc., is one to be accounted for by the use of alcoholic liquids, although this is not stated as the cause. Here are some of the statistical comments: —

"Commercial travelers, who lead mostly an out-of-door existence, have a mortality of 948. That a very considerable proportion of the mortality is due to this cause is apparent when it is noted that, under the headings *Alcoholism*, *Liver Disease*, *Gout*, *Suicide*, the mortality figures for this occupation come very high up on the list. The death-rate of tailors, 1,051, and that of shoemakers, 961, are both high. While both trades are sedentary, and somewhat unhealthy, much of the excess arises from those diseases which point to alcohol as a cause."

These are but specimens of very many other employments in which the statistical record points to an excess of diseases in which, in the opinion of the statisticians, the high proportion is mostly to be charged to the habitual use of alcohol, and often by those who were not regarded as intemperate.

15. Induration of portions of the nervous centers, congestion of the respiratory organs, and shrivelling and thickening of the coats of the stomach, are not un-

usual results of the frequent and habitual use of small quantities of alcohol. Still more serious is the effect upon the kidney and its functions. The power of alcohol to act upon the vaso-motor nerves of the capillary system, and to produce engorgement in minute vessels, is plainly shown in the reddened face and changed complexion of many habitual users who are not called excessive drinkers. The varied forms of renal disease which now destroy so many in middle life, or reduce them to invalidity, generally result from irritating substances, which find their way into the renal vessels. No irritant so frequently has this effect as **alcohol.** So marked and general is its effect in the way of inducing congestion of the capillary circulation of the system, and of most of its organs, and their subsequent destructive changes, that it has been well-termed by Dickinson the very "**genius** of degenerations." The stomach, the liver, and the kidneys are generally the first organs to be embarrassed in their functions by it. It then goes on to alter their structure so as to embarrass or suspend their service. One of the most constant and important revelations, both of pathology and of statistics, is that this occurs so uniformly in those who have been regarded as only **moderate** drinkers.

How the brain and the nervous system become involved in the disturbance is too well known, and too frequently attested by what we hear and see in the daily walks of life, to need extended comment. **Alcohol** retards the normal chemical changes which are essential to the processes of growth and repair. We need to give to the constructive forces full play. These are not stimulated, but blunted by alcohol. We cannot suc-

cessfully operate this wonderful machinery of life by forces which disturb circulation, disorder the nervous system, and embarrass vital organs both in structure and function.

16. When we come to examine into the different forms of alcoholic mixtures we find them differing in their injurious effects as they differ in the amount of alcohol they contain. We of course cannot expect so rapid results from cider and beers, with from 4 to 10 per cent of alcohol, as we have from wines of from 9 to 26 per cent; and from brandy, whisky, and gin, with their 50 to 60 per cent of alcohol. It is for the **alcohol** in them that they are used, and it is its use which constitutes the peril to health and to life. If needed, like ammonia, in prolonged faintness, or like the goad or the whip for the horse out of the reach of food, let the physician so decide. But because it is sometimes prescribed as a medicine, it has no claim for any ordinary use.

17. The deleterious effects of all alcoholic liquids have so impressed most governments that restrictive measures have been adopted as to the sale of such liquors, and their sale entirely prohibited or discouraged, so far as minors are concerned. Many who will not practice total abstinence for themselves are in favor of bringing up men and women entirely without it for at least twenty-one years. The foods which are found adapted to the first twenty-one years of life are sufficient for the rest of life.

18. Against the use of liquids containing alcohol in any form must be urged, not only that they are not needed as foods, but that their use is likely to create an appetite for them which is dangerous to health and to

life. In all the grades, from so-called moderate use to intensest intoxication, alcohol is fraught with fearful risks to health and life, as well as to character and success.

However proud we may be of our own powers of resistance, the universal testimony of experience is, that whatever tends to weaken our self-restraint is to be avoided. Fluids containing alcohol have shown such a wondrous ability to break down this power of **self-control**, and for creating a desire and appetite for such drinks, that, more than all other influences combined, they have overcome the resistance of the will, and proved the allurement and destruction of thousands.

Those who think they will stand, and those whom others have thought would stand, have fallen by multitudes. He who would do himself no harm must not run such a **risk**. The loss of self-control is a bodily as well as mental and moral **infirmity** often seen to pass from one generation to another. In any case, it involves in its consequences many more than ourselves.

Hygiene has no more imperative law, and no more persuasive words in behalf of health, than to say, "**Touch not, taste not, handle not.**" Character, education, health, happiness, and the hope of success, demand that life should be begun and carried through without indulgence at such a peril. It is a sad misnomer to call it drinking each other's health to drink alcohol. The fountain of health has not, and requires not, any such admixture.

19. **Condiments.** — There is a class of substances taken into the mouth which do not admit of classification with foods, but which have, nevertheless, some relation to digestion, and to the nutrition of the system. Some

of them are a hindrance thereto or an interference therewith.

In this class may be ranked the various peppers, catsups, and spices, essential oils and tobacco. We do not include among these common salt, since it supplies the blood with sodium chloride, one of its normal and necessary constituents, and also probably aids the stomach in the formation of its digestive juices.

It is also true of some of the condiments, that they have a slight food value. Thus mustard is a seed which has slight nutrient properties. But we speak of several of these as condiments because they are chiefly used as flavors, or from habit, or as stimulants to digestion.

Mustard, cayenne pepper, horse-radish, and ginger may be spoken of as those most used in their original forms as well as in combinations.

Epicures have studied some of these with great care, and chemists have sought to ascertain the secret of their excitation.

Olives, for instance, are claimed to stimulate the gustatory nerve, and the upper portion of the throat and epiglottis, and so to increase appetite.

Cayenne pepper, and some others, act upon the inner lining of the stomach, and temporarily increase the flow of gastric juice, so that they may meet the emergency of over-eating at the peril of ultimate injury It must be said of the most of these condiments, that, before they come into general use in the case of any one individual, he or his physician should be able to give some good reason why they are needed. For we know as to these, as well as some other articles, that

such over-taxing of organ or function creates a desire and a habit, and what was not a natural appetite becomes one. Hence the habitual user will be able to take them in such strength as would be unpleasant or even impossible for a person not accustomed to such use.

20. Black pepper, with its slight pungent and aromatic taste, shows by its ash unusual value as containing valuable salts, and a pretty constant quantity of phosphoric acid. Potash, soda, magnesia, lime, sulphuric acid, and a trace of iron are found. This gives to it a much more important place than that occupied by most of the other condiments. White pepper is the same berry, with a greater removal of its black husk or covering. Cayenne pepper, although in so frequent use in many sauces and catsups, is a direct and severe irritant. It is the cause of many cases of dyspepsia and other forms of gastric impairment.

Mustard, as noticed, has a small food value, and its acrid character is not so persistent as that of many other condiments. Such a mild irritant may be of occasional service. Thus a hungry man may be so situated as to have to eat a piece of tough meat, or eat nothing. No doubt thorough chewing, and a little mustard upon the meat, will aid the stomach in a digestion, which would otherwise be incompetent. These are the whips which may make indigestible things partly digestible. and give to exhausted stomachs a little more activity. But how much better it is to use digestible food and to have a capable stomach.

Ginger has much starch and gum, and owes its pun-

gency to a volatile oil, and an aromatic, acrid, soft resin.

Horse-radish is a root which is a pungent stimulant, and which has a slight nutritive value. It is rather more irritant to the stomach, and for this reason not so good for general use as either black pepper or mustard. As an appetizer, it is better than either.

Curry powders are mixtures of various condiments, such as ginger, garlic, black pepper, coriander-seed, etc., and can only be rated by the character of the materials used. Their first use was as a dressing for rice, to render it more palatable, among the natives of Ceylon and India. They have been imitated in various forms by Europeans.

Catsups and sauces, as now so extensively used, are composed of fruits, flavors, and condiments in order to cover the taste of some foods, to give special flavor to others, and to stimulate the appetite and digestive apparatus. It can be said of them, as a whole, that the prevailing use of them is excessive and very injurious. It is probable that the increase of diseases of the stomach and digestive apparatus, and especially of the kidney, are largely attributable to the use of so much of this kind of unnatural stimulation, but especially to those preparations made very hot with peppers and acids.

Delicate and appetizing flavors, such as those of fruits, acids, and oils, can be obtained without all this confection of irritants. Williams, in his recent *Chemistry of Cookery*, is so emphatic as to say that "thousands of poor wretches are crawling miserably to their graves, the victims of the multitude of maladies of

both mind and body that are connected with chronic incurable dyspepsia, brought about by the use of cayenne and its condimental cousins."

21. **Tobacco.** — It may seem strange to some, for us to place this among condiments. But it is an aromatic plant and leaf, and probably its sweetness and slight acrid taste, its **stimulus** and its power to appease **hunger**, had at first more to do with its use than any other cause. It has been variously claimed to be a food, a tonic, a condiment, a stimulant, a nervine, and an intoxicant. It is when we turn to a *materia medica*, or to some work on toxicology, that we find the fullest account of it. Its first free use generally causes giddiness, trembling of the limbs, faintness, depression, sickness of stomach, and cold sweats. The pulse is weak and quivering, the breathing hurried or embarrassed, and the vision impaired. In toxic doses, the action is on the central nervous system, producing failure of respiration. If the chewing or smoking has not been very excessive, the ordinary symptoms soon pass off. If its use is much less, or if a **toleration** of it is acquired, it acts as a beguiling sedative.

22. Whatever may be the ultimate accommodation of the system thereto, as with alcohol, a class of symptoms very different from those from the use of milk or meat or cereals or fruits tells us that it rightly finds its classification among articles unfriendly to the best health or to the nourishment of vital forces. Its most decided effect is upon the functions of organs rather than upon their structure. As a rule, it is not near so apt to make change of structure as is alcohol. Yet permanent changes, especially to blood-vessels and the nervous

system, result therefrom. Woodman and Tidy, in their volume on *Forensic Medicine and Toxicology*, speak thus: "Excessive smoking has proved fatal, as in the cases recorded by Gmelin, when two men smoked seventeen and eighteen pipes respectively at one sitting. Mr. Smith of Sheffield records two cases of paralysis of the portia dura directly caused by hard smoking." There is a general testimony that dyspepsia, heart palpitation, and nervous symptoms often result therefrom. Its evil effect upon young persons has been accurately set forth by Dr. Decaisne,[1] and Dr. A. C. Gorgas,[2] Medical Inspector, U. S. N. This testimony is the more significant because there was a return to the use of tobacco on the part of the students of the Naval Academy, but the contrasted facts caused a subsequent renewal of the order to desist from its use. The evidence has been such from other sources that a prohibitory law applicable to youths has been enacted in Germany. While during the growing period of life all are more susceptible to the evil effects of tobacco, those of full age are affected in a milder degree. There is a constant tendency of the habit to increase.

23. Even among those who have the belief that the moderate use of tobacco does not injure all persons, there is such agreement as to its effect upon the young, that most of them favor laws which make it a punishable offence for those under age to use tobacco in any form.

There is reason to believe that our young population is being greatly injured thereby, and also that the use of tobacco has become so general, and often so excessive,

[1] *British Medical Journal*, September 26, 1868.

[2] Am. Pub. H. Asso., Vol. VII., pp. 230–240.

among adults as to be traceable in special injurious effects upon them and their descendants. **Tobacco-smoking** increases pulse-rate. Both in chewing and smoking there is an unnatural stimulus of the salivary glands. Their office as aids to the first process in digestion is interfered with. While it is true that the evil effects of very occasional smoking are transitory to many, it is equally true that the excess in the habit which generally occurs makes in time a permanent impression upon the nervous system.

Its effect in **checking growth** is unmistakable. So far as the young are concerned, it is doing more harm to bodily health than alcohol. A substance which will produce such profound impression as it does when first used, and which has caused death when applied for a long time to a raw surface on the body, and which has by its irritation induced cancer, surely ought not to be in ordinary use among mankind.

24. The **cigarette** has been found to be even more harmful than the other forms of smoking. Besides many evils which its use involves, not the least is one already noted as to alcohol. It not only becomes a habit that it is hard to abandon, but the very failure which so many make in their efforts to quit its use shows too plainly that it undermines the power of self-control, and so is a weakening of that vigor of trained will, of that mastery of self, which is a part of the physical as well as of the intellectual welfare and prowess of manhood. As an interest both of the individual and the state, the use of tobacco in any form by children should be prohibited under proper penalties. As a matter of public and personal health, and in the interests of the vigor of the coming generation, this restraint is demanded.

Some of the States have already passed laws prohibiting the sale of tobacco to those under sixteen years of age.

There seems to be good evidence that modern modes of life, and the pressure of excessive business, incline many to indulge in that class of substances which produce a slight exhilarating effect, followed by a calm such as occurs in the first stage of narcotism. There is great occasion for the young to guard themselves against all plausible excuses for any of these indulgences. We have never known any one to regret **abstinence** from them, and have known very many, in the moderate use of some of the milder forms of excitants and sedatives, to be earnest in advising against the acquirement of such habits.

Chapter XIV.

MODES OF HEATING.

THE first division of the subject of Heating is into what are called **natural** and **artificial** systems. The truly natural system is where we depend upon the natural warmth of the body and the heat derived from the sun. Clothing and change of position are merely our methods of adapting ourselves to changes, and are found sufficiently available under various circumstances. While these cannot be entirely depended upon, they are nevertheless to be emphasized. Those who build houses with a southern exposure, and with windows giving good access to light and heat, and yet interrupting draught, have practically carried out this idea. **Clothing,** and proper changes of clothing, and the use of such garments as can be easily put on or off at pleasure, are to be considered. It is fitly urged, that we may become too dependent on such forms of artificial heat as are furnished by fire.

2. It is always to be remembered that the **body** itself is a heat-producer, and that exercise and care of the skin, and proper quantities and kinds of **food,** and good **sleep,** have much to do with the generation and utilization of heat. We must not educate ourselves or our children to be more dependent on fire heat than is necessary. Those who too constantly hover around the stove, or who so receive heat as that one

side of the body is overheated and another part exposed to cold or draught, are not enough impressed with the need of availing themselves of the strictly natural sources of heat to a degree that shall limit the demand for purely artificial methods. Where the thermometer is at 70° F., and here and there a person feels too cool, there must be inquiry as to any improper source of draught, or else such person should have more clothing, more food, or better health.

Our need for special sources of heat arises from the variations of actual temperature, and from the necessity of surrounding ourselves with houses in which there are many artificial arrangements. Besides the heat contained in our bodies, warmth is conveyed to us by one or all of the three methods of radiation, conduction, and convection.

3. **Radiation.** — **Radiation** is the giving off of rays of heat from a heated surface. The rays diverge in straight lines from every part of a heated surface, and from minute depths below the surface of hot bodies. The **radiation** may be increased by increase of the surface and by improving the nature of the surface. Radiation takes place in vacant space, that is, in a space containing no form of matter which we can weigh, as well as in the midst of certain media called **diathermanous.** Air, glass, and other bodies, which, in general, freely allow light to pass through them, are examples of such diathermanous bodies.

Conduction. — When heat is communicated from molecule to molecule of a body, while the molecules retain their relative places the process is called **conduction.** This process is illustrated in the action of

most solid bodies, especially the metals, when one portion of such bodies is raised in temperature above the other portions, by being brought in contact with a hot body. When one end of a poker is thrust into the fire, the temperature at the end is raised by the fire and the process of conduction is at once set up. The conducting power of different substances is very different. Thus, that of copper is 89.92, while that of iron is 37.43, and of zinc 36.30.

Convection. — In general, when liquids are heated, the portions first heated become thereby expanded, and so rendered specifically lighter than the remaining portions. Owing to the almost perfect freedom of motion among the particles of such bodies, the expanded portions are displaced upwards, while the heavier particles sink down to take their places, and, in turn, become heated and rise in like manner. This process of heat diffusion is called **convection.**

Where there is reliance on **natural** heat, the building or room is so located as to command the greatest amount of heat from the sun and the least wind, also the laws of conduction and non-conduction are recognized, and the materials, and even the colors, used for the room are such as will secure for it the most heat without any artificial source of heat.

4. The most usual methods of artificial heating are as follows:

I. By heating the air of the room.

II. By heating air outside of the building or room, and conveying it into the room.

The sub-divisions of the first method are chiefly these:

(*a*) By fire in a fireplace, or its equivalent.

(*b*) By fire in some form of stove.

(*c*) By radiators, or pipes heated by hot air or hot water or steam, and located in a room, but heated from the outside.

Of the second method we have the following varieties:

(*a*) By furnaces, the heated fresh air of which is introduced through registers.

(*b*) By radiators of various forms located **outside** of the rooms, heated by various methods, over which fresh air flows, and, being warmed, is let into the rooms.

The general objection to all forms of the **first method** is that it involves the heating of air which is in the room, and so of air which is undergoing deterioration. We shall see, however, that this statement admits of some modifications. The general recommendation for the **second method** is that it admits of the introduction of air properly prepared for breathing. As a rule, it is more expensive, although in a matter so affecting health this should not have too large consideration.

5. Under the head of heating by heating appliances in the room, our first example is **the fireplace,** in direct connection with the chimney, with its wood or coal fire. This is admitted as being a healthful mode of heating. The fire and the chimney thus become ventilators, by drawing toward themselves the air of the room, which is re-supplied from various cracks and crevices. Where there is a very strong draught, it may occasion rapid currents in the room. The chief objection to a fireplace in the chimney is, that it is difficult to secure an amount of heat sufficient for an entire room. The only heat

secured is that by **radiation.** Much heat goes up the chimney, and the consumption of fuel is large in proportion to the amount of heat produced.

To increase the throwing out of the heat, and to prevent so much going up the chimney, various plans have been devised. One of the earliest of these was the Franklin fireplace heater, by which it was sought to deflect more of the heat into the room. Changes in the throat of the chimney, and in the mode of setting the fireplace, have also been made, in order that less heat might be drawn up, and yet a proper draught be secured. The brightness of metals and other choices of radiating surfaces have been made in order to throw out the heat into the room.

So valuable has the **fireplace** proved as a means of ventilation, and so available is it also as a supplement to other modes of heating, or for mild or damp weather, that there are those who, regardless of what may be the other particular modes of heating, advocate the fireplace for ventilation.

6. The next mode of heating is by fire in some form of **stove.** Here the air for draught is drawn from the room, thus, like the fireplace, inducing an inflow of air from without. By radiation and conduction heat is distributed through the room, and thus the air that is in the room is heated. With the best form of heating apparatus, and proper management, this mode of heating is compatible with purity of air. The value of the fireplace and of the stove is thus illustrated by Prof. C. O. Curtman: —

"Using an ordinary stove, and selecting as fuel anthracite which contains about 98 per cent of pure carbon, we find that

for every pound of fuel burned, two and two-thirds pounds of oxygen, measuring about thirty-two cubic feet, are consumed. This corresponds to nearly 160 cubic feet of air. As much air escapes through the chimney unburnt, we need not wonder that Regnault's experiments led him to nearly double that amount, and assume that 312 cubic feet of air are required for every pound of anthracite burnt in a stove.

"A school-room twenty by thirty feet in extent, and twelve feet high, contains 7,200 cubic feet of air, weighing about 540 pounds. If, during a cold winter day, 300 pounds of coal are burnt in the stoves of this room, there will be (according to Regnault) 93,600 cubic feet of air, weighing over 7,000 pounds, passing through the stove into the chimney. In other words, by the mere automatic ventilation produced by the burning of the fuel, the room, containing 7,200 cubic feet of air, must be emptied and refilled thirteen times in a day; but as the period of active firing does not usually occupy more than nine hours (from 7 A. M. to 4 P. M.), the air is emptied and replaced about once in every forty minutes during school hours. Within these forty minutes fifty children would inspire about 600 cubic feet of air, from which they would remove about 6 cubic feet of oxygen. The rate of ventilation in such a room, produced automatically by an ordinary stove consuming 300 pounds of coal, is therefore more than sufficient for even a greater number of occupants, and, in warmer days, when only one-fourth of the fuel is consumed, ventilation will still be active enough for all purposes."

This, of course, will not be true, to the full extent, if the stove is air-tight, except in that portion of the room near where air for draught is admitted. But with this frequent aid, and if the stove door be often open, or the space not tight where the pipe enters the chimney, much ventilation is secured.

7. Several points need to be carefully guarded. First, if, in this method, a good draught and perfect **combustion** are not secured, much of coal-gas and its compounds pass into the air of the room. These consist of carbonic acid, carbonic oxide and sulphur, and other compounds, and much deteriorate the air. Where an attempt is made to moderate or regulate draught by a damper, this often adds to the evil. If, on the other hand, the stove becomes overheated, or is loose-jointed, carbonic oxide comes through the joints of the stove or through the heated metal, and deteriorates the air by its poisonous qualities. Carbonic oxide is always formed where the supply of air for draught is insufficient. Headache and lassitude are more frequently owing to this than to a general foulness of air. While base-burners, as they are called, do not let out much gas in filling, they need to have good draughts. They do not aid much in ventilation. Pipes or stove-flues, filled with soot or dust, often impair the draught in good chimneys.

If the heat for warming the air is to be generated in the room, it is very important that there shall be perfect **combustion** to an extent not to allow any gas to enter the room from the stove. This presupposes an adequate supply of air and a good draught of the smoke-pipe or chimney.

Where the draught is otherwise complete, the turning of dampers, or the opening of the stove door, while putting in the coal, may cause the presence of gas in the inbreathed air. A great deal of trouble with stoves and furnaces comes from imperfect draught of chimneys, or from too small an air inlet to the coal. Excess of **fuel** over air produces imperfect combustion by lack of oxy-

gen, while excess of **air** over fuel produces imperfect combustion by diminution of temperature.

8. Supposing that a proper supply of fresh air is in some way reaching the room, and that the heating apparatus in the room is heating it, a question arises as to the **dryness of the air,** since our sensation of heat is affected thereby. One effect of heat upon air is to raise its point of **saturation.** One cubic foot of air, say at thirty-two degrees, is capable of containing a certain amount of moisture, and no more. If we raise it to a heat near that of the human body, it is capable of containing much more, and consequently absorbs moisture from everything that contains any. The heating of the air does not dry it in the sense of extracting moisture from it; it only increases its capacity of containing water, thereby rendering it more absorbent or thirsty.

Our difficulty here arises from the fact that air may be too rapidly increased in its capacity for moisture on the one hand, or may be saturated with moisture on the other. When the temperature of air cannot be diminished without depositing water upon the walls or window-panes, or without its appearing as a mist, it is said to be saturated. If the temperature of saturated air be raised, it will become drier to the senses, and will immediately begin to take up water which is exposed to it.

Air is dry or moist, not in proportion to the water it contains, but in proportion as it is more or less removed from the point of saturation. The point of saturation rises more rapidly than the temperature.

9. A glass tumbler filled with cold water in summer is soon bedewed with moisture, because the air around it is cooled, and its moisture precipitated upon it; the

same occurs in winter if the tumbler is brought into a close room in which many persons are assembled, and in which the air is loaded with the accumulated vapor exhaled from the lungs and skin. For the same cause, in winter the cold windows of a crowded room, not provided with efficient ventilation, are constantly covered with minute drops of water, which soon collect and run down the glass in streams.

The highest point of the thermometer at which vapor begins to be deposited by the air is called the **dew-point**; it is the point at which dew begins to form. The humidity of the air is practically measured by the difference between the dry-bulb and the wet-bulb thermometer.

A temperature of from 65° to 80° F., with a saturated atmosphere, becomes sultry and oppressive. The surplus heat cannot be removed by conduction or radiation, and the natural effort of the system is to produce evaporation. Above 80° F., a saturated air becomes most oppressive. Air may be considered dry at 35° F., that is to say, its capacity for moisture at that point is low.

It is because the capacity of air for moisture is so rapidly increased by warming, that, in a climate like ours, it is more apt, in rooms, to lose moisture too rapidly than it is to be over moist. Air, suddenly heated, appropriates to itself moisture that should be left for our use.

We can somewhat prevent the air from appropriating too much of the surrounding moisture, if we provide for it an additional source of supply by warm water or an evaporating-pan. Different states of atmosphere require different quantities. Under usual circumstances, in rooms having stoves, the evaporation of half a pound of water an hour gives a moderately dry and healthy

atmosphere. A sponge moistened from time to time, and kept hanging in front of a register, often adds to comfort, because it aids partly as a filter to retain dust, and is a source of moisture. Vessels of porous clay, placed upon the register, have also been used as a means of adding moisture.

10. Another point bearing on modes of heating is that made by Hood: —

"There are always suspended in the air myriads of particles of animal and vegetable matter; but these almost unheeded atoms possess a high philosophical importance, however they may, generally, be disregarded. Many of these particles are easily decomposed by heat, and are then resolved into their various gases, either in their elementary or mixed state. Hence many of the methods of producing artificial heat are materially affected, as regards their wholesomeness, by the fact of their being able or not able to decompose or chemically alter these floating particles of matter. To this cause is mainly attributable the unpleasant smell produced by several modes of warming buildings, by highly-heated metallic surfaces; and we have already seen that the **hygrometric** and electric condition of the air is also altered by the same means. All the different descriptions of hot-air stoves are more or less liable to these objections; as also the high-pressure system of hot-water apparatus, and still more the cockle or hot-air furnaces. Dr. Nott's stoves, and also the Russian and German stoves, are subject to this inconvenience; and **asphyxia** is frequently produced in Russia by the use of these stoves. The cockle or hot-air furnace is particularly liable to these objections; for not only will it act powerfully in decomposing the floating particles of extraneous matter contained in the air, resolving them into sulphureted, phosphureted, and carbureted hydrogen, with

various compounds of nitrogen and carbon, but it will likewise decompose a portion of the vapor contained in the air, absorbing the oxygen and liberating the hydrogen.

"Carbonic oxide is generated by all stoves which are constructed so as to burn with a very slow draught. The carbureted hydrogen is abundantly produced by the gas-stoves, in consequence of a portion of the gas escaping unburned from the stove; and this unburned gas, when combined with the large quantity of vapor which is produced by the combustion of carbureted hydrogen, as already described, renders these stoves peculiarly unwholesome. All these causes of deterioration of the air affect different persons in very different degrees; but wherever the causes exist the result will necessarily be derangement of the animal system, however robust the persons may be who are exposed to their influence; but, of course, the sensations will be soonest experienced by the delicate and the valetudinarian."

It is still worse if the cylinder is permitted to become red-hot.

Hot stoves cause a dry or burnt condition of air, which it is difficult to describe, but which leads those accustomed to wood-fires, or to other forms of heating, to speak of the heat as not agreeable.

11. The dust and dirt connected with the fixing of stoves also loads the air with many particles. Care, and an understanding of the evils to be overcome, will enable us to guard against many of these disadvantages. As **stoves** will continue to be the dependency of very many homes, it is well that these risks be thoroughly appreciated. Stoves, more than modes of heating from outside, need good provisions for **ventilation.** For as the air being warmed is that of the room, it soon becomes foul, and should have some mode of

exit. This should not be by holes around a pipe into the bed-room above, which, unless the lower room is very open, thus becomes the storehouse of the hot and foul air of the lower room. A side flue so near the chimney as to be warmed by it may have a movable ventilator set in both above and below, and aid much in the ventilation.

12. Where the heating is by hot **air**, or hot water, or steam, brought into pipes running along the walls of a room or through radiators, it is to be remembered that we are still heating the air of the room, and not introducing fresh heated air. It is true that we get clear of some of the disadvantages of stoves. The heat can be more equally distributed to different parts of the room, and can be more evenly regulated. There is no escape of stove gases, and none of the dust connected with stoves. The mingling of carbonic oxide with the air is not so common, and an overheated or burnt condition not so often complained of. On the other hand, it is heat without any of the possibilities of ventilation which are more or less incidental to stoves, stove-pipes, and fireplaces. Unless there is provision for natural or artificial ventilation, it can be made a form of heating in which the contamination of air rapidly takes place. For assembly-rooms, schools, and other public buildings, it is usually preferred to stoves, because convenient, or because special systems of ventilation are associated with it. A **fireplace** with a small fire in such rooms is often wisely used as one of the aids to ventilation, if not for heating.

Where such pipes are heated by **hot air** they are subject to those changes which occur in heated metal

by the alternations of temperature, and may, by their joints, let out some of the gases of the fuel or of imperfect combustion. Pipes which are warmed by **hot water** circulating through them can have their heat regulated with exactness, and so are free from the objections arising from the direct application of heat to iron. With water under ordinary atmospheric pressure, a mean temperature in the pipes of over 160° or 180° cannot be secured. Some aid is obtained by increasing the velocity of circulation. Greater heat is secured by hot water **under mechanical pressure,** as the radiation of the heat to the room becomes more active.

The use of **steam** for heating pipes has similar advantages, with some increase of effect. For similar reasons that water under pressure accomplishes more than water at ordinary atmospheric pressure, steam with its elasticity and quickness of movement conveys heat to the air with greater rapidity. Both for water and steam under pressure there must be such construction and management as to insure safety.

13. We next consider those modes of heating in which **air** is introduced, or intended to be introduced, into a building or room in a condition pure and **warm** enough for comfortable breathing. The fireplace and the stove have been so modified as thus to furnish to a room a supply of outside air warmed.

One plan for doing this is illustrated in the **Galton grate,** where cold air from without is let in around the rear of the grate, and, being warmed, becomes diffused from the sides of the grate into the room. Another plan is, where a stove is surrounded by a metal case, or "jacketed," so that cold-air is let in around the stove,

and being heated ascends above the jacket and is diffused in the room. The accompanying diagram illustrates the latter method. In each of these cases, the air for

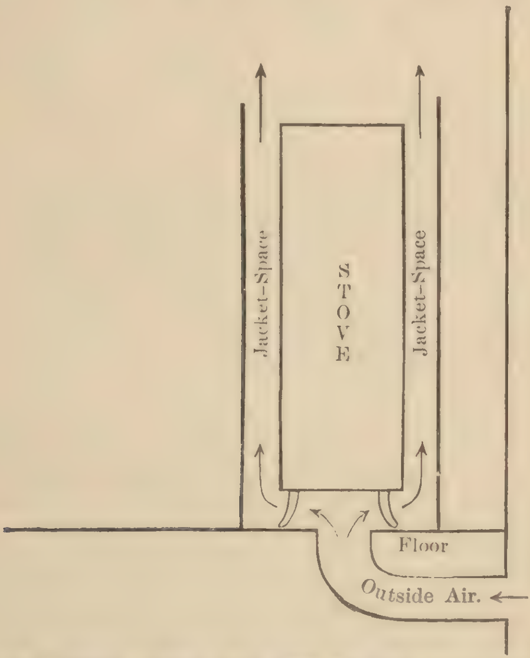


FIG. XXIV.—Stove with fresh-air inlet and jacket.

the **draught** of the stove or grate is derived from the room, while the air that moves about the grate or the stove, inside of the jacket, comes from outside, and is diffused through the room, as pure air for breathing.

14. The most common form for the introduction of warm air into cold rooms is by the **furnace.** Introduced originally only as a mode of heating factories,

it came into popular use without a full consideration of its relations to heated air and ventilation.

At first it was, and, to some extent, it still is, merely a big stove below a room, instead of in it, and the substitution of the heated air of the cellar, or of the ground around the cellar, for the air in the upper room. Too often this is no improvement, either for heat or for ventilation.

The **cellar** supply of air is seldom as pure as that above ground, and frequently where attempt is made to furnish outside air supply, a great deal is still drawn from the basement. In the putting in of coal more dust is made, and the door is longer open, and so dust and coal-gas from this source, as well as from imperfect combustion, freely find their way to the rooms above.

In the effort to make one furnace do for a house, pipes are often so arranged as to lose much heat, and the smoke-pipe has such a horizontal or circuitous course as to diminish draught, and to become overladen with coal-dust and soot.

15. To meet the first of these objections, it is usual to have what is called a **cold-air** box, so that air from out of doors may be let in **around** the **heater,** and, having become warmed, pass into the pipes connected with registers, and so into the rooms. In such a case the **draught** air for the furnace is that of the cellar. If each furnace could be so connected with the **outer air,** and jacketed, that none but the outer air could get to it, and so be warmed as in an air-chamber, and thus conveyed, it would accomplish more than is now generally secured.

The cold-air box should in any case be used with

a sieve or wire-gauze to sift the air coming in, and should be **very tight,** so that the cellar or draught air cannot get into it, and should be so arranged that the air may be distributed about the furnace. In windy weather it needs regulation, to secure the proper heating of the introduced air.

The heated air brought into the room should never be at a temperature higher than 170°, but is often 200° F.

16. The air thus warmed and introduced into the room, unless distributed by several registers, comes in too much at one point, and has the same or even greater disadvantages as to overheated dust and over-thirstiness for moisture that the stove in the room has.

An evaporating-pan on the furnace, or one hung in the register just where the heated air enters the room, is of some service. Attempts have been made, by means of a movable top to the register, to have cloths or sponges that will also sift out some of the dust and moisten the air. It is well to have the registers so arranged as to admit of this kind of adjustment.

Furnaces must be classed as a hazardous method of securing pure warm air, and should be subjected to the various tests to determine the purity of the introduced air. The methods of ventilation adapted to rooms heated by furnaces will appear in the general consideration of ventilation.

17. The next method of heating to be noted is that of **indirect radiation,** in which it is attempted to thoroughly prepare the air in every respect before it enters rooms or buildings. It is passed over a series of tubes or radiators variously heated and arranged so as to

secure ample radiating surface **outside the rooms,** and utilize the heat for introduction. It is not necessary to give in detail all the various methods adopted. They extend to modes of moving fresh air rapidly over these radiators, either by high chimneys or fans; to an indefinite use of radiating surfaces and the use of felt and other wrappings for retaining heat, and of conductors and non-conductors, variously applied.

In some cases, as in the English Houses of Parliament, the air is passed through coarse cloth sieves, and is constantly moistened by sprinkling apparatus, and then introduced with right temperature and velocity through perforated floors. It is an attempt to secure, for houses, outside air fully prepared for use, and has been very successful. Cheap as outdoor air is, when thus dealt with, it is quite costly, but valuable.

It is a general principle, in all methods of indirect radiation, that the **whole air** should be warmed to the degree necessary for introduction into rooms, rather than that air should be very highly heated in this outside chamber, and then brought to a proper temperature in this chamber by adding thereto cold air from without, so as to make it fit for the rooms. As the various modes of conducting indirect radiation, and the fixtures required, do not come under household regulation, we only need to point out the general method of adaptation, and the object sought.

18. In **all** methods of heating, more attention needs to be given to the effects of imperfect or interrupted **fire-draught,** and to the evils of imperfect combustion of the fuel used. In fireplaces, and with wood-fires, this so declares itself by smoke or by a feeble fire, that it is

soon recognized. But in the various forms of stoves and furnaces, the fouled air that gets into rooms from this source is very considerable.

Chimneys should be so built as to shape and caliber, as to smoothness of inside surface, as to pipe connections in rooms, as to position in walls, and free height above roof, as to secure good draught. Often the course of the smoke-pipe is too circuitous, or it runs horizontally so far as much to diminish draught, even where the chimney is not defective. The filling up with dust and soot is another difficulty, to be remedied by frequent cleansing.

Sometimes the draught can be much improved by some form of apparatus attached to the top of the chimney, usually known as a **cowl.** Some of these caps or cowls are chiefly valuable as keeping out snow or rain. The chief object of cowls is to present such a surface to currents and winds as to cause an aspirating or suction effect on the air below in the chimney. It is well known that a wind blowing across a cylindrical tube causes a suction or aspiration. These cowls are made so as to adjust themselves to the direction of the wind.

19. There is no source of ill-health so prevalent as that dependent upon ill-regulated temperature, and its almost necessary accompaniment of impure air. By knowing what are the conditions under which the various forms of heating are to be applied, and by testing the actual state of the room air, those who are intelligent and observing will be able to remedy many defects, or so appreciate them as to seek skilled advice.

The great difficulty as to all systems is, that, in order

to know whether this plan or that plan is the best, all the local complications must be duly considered. Even where the system is in general correct, imperfect management, or a failure on the part of the person in charge to adjust the amount of heat or the plan of ventilation to the variation in the number of persons, in the state of atmosphere, and in the condition of inmates, may make all the difference between wholesome and unwholesome air and a well-regulated temperature.

20. It is very important that all school-rooms, or public assembly-rooms of any kind, have definite and well-understood methods of heating and ventilation, and that they be placed under skilled management. The various forms of pulmonary disease make up a very large proportion of the causes of death. They are equally the cause of prolonged invalidity. In school life, the foundation is laid for very many diseases of the respiratory apparatus, that only become fully apparent in the disabilities of more mature life. Heat is the motive power in ventilation, and the greatest complications, as to the air we breathe, occur in winter, when we are dependent upon it. No physical experiments are so important as those that determine the daily purity or impurity of the air which is heated and furnished for indoor life. Pure air is a vital concern in education, and, especially in the interest of the rising generation, must be furnished.

CHAPTER XV.

VENTILATION OF HOUSES.

ALTHOUGH we have already considered air in general as related to health, and some of the conditions of air in houses as related to artificial heat, the modes of securing proper **ventilation** demand further consideration. Our special need of ventilation in houses arises from the fact that the dust, gases, etc., incident to house-living, tend to deteriorate the air, and that we ourselves, in the process of life, are burning out or consuming the oxygen which it contains, as well as conveying to it decomposable or organic matter and noxious gases. The fires, the gas-jets, and everything that has breath and life within the house, tend to exhaust the air of its life-sustaining properties, while the myriads of floating particles load it with organic matter more or less unfriendly to vital purity.

2. The **atmosphere** provided for us is composed of three gases, — oxygen, nitrogen, and carbonic dioxide, usually known as carbonic acid. With these the **vapor** of **water** is always associated. The first two are usually called essential elements, but water and carbonic dioxide are so far accessory, that air is never found, in nature, absolutely without them. The oxygen, nitrogen, and carbonic acid form a simple mechanical **mixture** which is very perfect, although the same bulk of these gases has each a different weight. When thus

mixed, the diffusion of gases is so perfect that they do not separate, except as they come in contact with some substance which will absorb or combine with some one of these constituents.

3. The usual proportion in which these normal components are found is about as follows: Nitrogen, 79; oxygen, 20.96; carbonic acid, .04. There are slight variations, within a range which cannot be said to affect human health. **Ozone** is oxygen in a peculiar state, but as it is not usually found in the air of dwellings, it need not be treated of here. The active principle in the air, in its relation to breathing, is **oxygen,** so that any considerable variation from 20.96 per centum at once indicates deterioration. If the proportion comes to be as low as 20.60, the air is to be regarded as bad.

The quantity of **nitrogen** may become of undue proportion because of the diminution of the oxygen, but does not, by any actual excess, become a danger to life. It is only when we come to the artificial conditions of in-door life that we find any great change from the normal constituency of the atmosphere. This change chiefly consists in a decrease of oxygen and an increase of carbonic acid. **Pure** carbonic acid may be present in the air to the amount of fifty or more parts in 10,000 without serious inconvenience, but if the carbonic acid present is the result of the burning out of the oxygen of the air, as in the process of breathing, the case is far different. It then indicates to what degree there has been a diminution of the oxygen of the atmosphere breathed; and because the amount of organic or decayable material present in the expired air bears a

pretty regular proportion to the amount of carbonic acid exhaled, it becomes a measure of this also.

When the normal amount of 4 in 10,000 is increased to 6 or 7, the air is apt to seem close to a person entering from the outer air. This will be a little modified by the condition of the person, and the temperature of the air. A room is stifling when the amount is as high as 8 parts to 10,000.

4. House air that is not **habitable** generally owes its unfitness for breathing purposes to one or all of the following conditions.

(*a*) The undue deficiency of oxygen and undue increase of carbonic acid.

(*b*) The addition of ammoniacal and other nitrogenous products and various gases of imperfect combustion.

(*c*) The addition of dusts and various particles of an animal, a vegetable, or a mineral nature, some of which irritate in their processes of growth and decay, and some of which irritate mechanically.

(*d*) Such heat and dryness of air as causes it to make too great demands upon our bodies for moisture.

(*e*) Such heat and saturation with moisture as prevents the air from readily taking up the perspiration or other secretions of our bodies.

(*f*) Such sudden changes of air as expose us to draughts and to such changes in temperature or in perspiration, as produce colds, irritation, or congestion in parts of the system.

The **adjustments** and **compensations** necessary to overcome or modify these conditions in our indoor life are the chief subjects of consideration when we speak of ventilation.

5. The **first** condition is usually due to the presence of living beings, of fires or of gas, lamp or candle lights in the room,—any and all of which appropriate the natural oxygen of the air, and substitute in its place carbonic acid. A person, in passing the usual amount of 350 or 400 cubic feet of air through the lungs each 24 hours, appropriates about 18 cubic feet of oxygen and exhales a little over 18 cubic feet of carbon. Air which has been breathed once has lost about 5 per cent of its oxygen, and has gained a little more than 5 per cent of carbonic acid. A pound of anthracite coal in a common stove consumes $2\frac{2}{3}$ pounds of oxygen, or about 32 cubic feet. A candle burning at the rate of 120 grains of spermaceti an hour, which is the English standard of comparison, consumes about one-half as much oxygen as a man. The combustion of 1 cubic foot of coal-gas consumes the oxygen of 10 cubic feet of air, and produces 2 cubic feet of carbonic acid.

6. The **second** and **third** conditions are caused by various forms of minute particles that are brought into the dwelling or separated by the wear of articles therein, the various dusts and gases from fires and lights, and especially the organic and decayable materials given off by the body in breathing, and in its other processes of waste and repair. The varying amount of decomposable particles given off by the body in 24 hours is estimated at about 300 grains. Of this, the amount of animal organic matter from the lungs may be estimated as 30 to 40 grains per day for each adult. It consists of small particles of skin, epithelium, fatty matters, and a peculiar fetid, organic vapor, which is the cause of the disagreeable odor in close and crowded

rooms, and gives rise by its decomposition to products detrimental to health. If this air be passed through water, the latter soon exhibits all the phenomena of putrefactive fermentation. The amount of vapor of the skin and lungs together is about 30 ounces per diem. These materials vary much in quantity and the rapidity of decomposition. When we have many persons together, as in an assembly or school room, this source of contamination is rapidly multiplied.

7. The **fourth** condition,—**heat** and **dryness** of the air,—is important, because moisture, as well as the heat which the thermometer registers, affects our sensation of warmth, and has much to do with health conditions. In the chapter on HEATING we have already presented the method by which the body equalizes its moisture as well as its temperature.

8. If the air is hot and dry it makes constant demands upon the water of our bodies. About nine ounces, or more than half a pint of watery vapor, as an average, is given off from the lungs every twenty-four hours. The quantity of insensible perspiration is about twice as much. When we heat the air we increase its capacity for moisture. In its effort to claim this, it seizes upon our bodies as one of its sources of supply, and thus makes us uncomfortable, unless we can constantly compensate therefor.

On the other hand, the saturation of air with moisture prevents that free transpiration from ourselves which is necessary to comfort. In either case, we are oppressed, and must seek a supply of pure fresh air, and of air so in motion as to make up for these special conditions.

9. In providing for the **sixth** condition, we have, on the

one hand, to secure the needed change of air, and on the other to so introduce the air as not to cause dangerous draughts. When the external temperature is warm, there is little risk in doing this with windows or doors wide open, the chief risk being from sitting near small holes where the air can rush through in the form of a concentrated current like that from a bellows. But where we are dependent upon the heat of the room, it is very important that the air does not enter with too much draught. Even if it is fresh warmed air, it may be introduced with such a current as to cause undue heat and dryness to those within its range.

This feeling of **draught** depends, in part, on the velocity of introduction, and, in part, on other conditions. The **warmth** of the moving air influences the sensation of the persons exposed to it. At a temperature of 55° or 60°, a rate of 1½ feet per second (or about 1 mile per hour) is not perceived; a rate of 2 and 2½ feet per second (1.4 and 1.7 miles per hour) is perceptible to many persons; 3 feet per second (2 miles per hour nearly) is perceptible to most; a rate of 3½ feet is perceived by all persons; any greater speed than this will give the sensation of draught, especially if the entering air be of a different temperature or moist. If the air be about 70° F., a rather greater velocity is not perceived, while if it be still higher (80° or 90° F.), the movement becomes again more perceptible. This is also the case with the temperature below 40° F.

10. Our power of introducing air into a room without draught depends upon the **size** of the room, the **number** of persons to be supplied with air, the relative **temperature** of outside and inner air, and the **mode** of introduction. In a small room, it is more difficult to have

the air distributed before reaching the person, and so he may feel a draught. Where there is a number of persons, the air must be introduced more rapidly, unless there is adaptation of size of room and modes of introduction thereto. We have already noted variations made by temperature and moisture. If the air comes in through some direct inlet, and nearly all at one or two points, more draught is likely to occur. Smallness of opening may give direction to the current, as where a hole in a pane of glass directs a current upon some exposed part of a person near by, and causes a draught which a wide-open window would not. As a rule, we are not so likely to have draughts when the air is introduced at various points in small quantities, instead of at two or three points in large quantities.

We also do much to prevent the sensation of draught if we introduce it above the heads of persons occupying the room, and in such wise as to secure for it a slight ascent. Thus, if the lower sash be raised and a tight-fitting strip of board be placed under it, the only inlet will be near the middle of the window, between the lower and the upper sash. The upper part of the lower sash serves to give to the air, as it enters and gains a little heat, a slight upward motion. The direct current of the air is intercepted. It is also true that if a wire gauze is put in under a sash, or at the upper part, it cuts the air so as to diminish the draught.

11. The amount or **air-space** needed by each individual depends primarily upon the amount of oxygen that is being burnt up or removed from the air of the room.

Our first data are derived from the amount of air consumed or deteriorated by each person. If every

breath took out only a certain amount of air and its oxygen, and the expiration or outbreathing of the air from the lungs did not return to the room, the problem would be a simple one, for new and pure air would take the place of the air extracted by breathing. But a cubic foot of air, as it comes from the lungs in ordinary respiration, has lost most of its oxygen, and contains, instead, upwards of seventy cubic inches of carbonic acid, besides organic matter and fouled watery vapor. This air has not only been devitalized, but infused with injurious particles.

The need of air-space or ventilation also depends upon shape of room, height of ceiling, floor-space, etc.

12. With all these facts in view, those who have most carefully considered them, and have tested by experiment also, claim that in a room ordinarily tight 2,000 cubic feet of air must be admitted each hour for each person in it. This is based upon the conclusion that, to preserve the standard of purity, about 650 feet of air is actually needed each hour for each person. But as practically we cannot change the entire air of a room oftener than three times an hour without draught, we must introduce three times the amount actually used up.

The amount of **cubic space** required for each person has been stated as from 250 to 300 feet for dwellings, school-rooms, etc., while for tenements, hospitals, etc., it should be much more. As school-rooms are not occupied all the time, and give opportunity for air-flushing during and after school, from 25 to 30 cubic feet of air per minute for each person will answer.

As **height** of ceiling over twelve feet is not counted, this would give to each person in a room, or to each

scholar in a school, a floor-space of about four feet by five, or five feet by five.

13. It is well to consider all the various theoretic needs and modifications, because they help us to attain to accuracy. What is called experience needs to be tested by scientific facts, just as scientific facts need to be tested by experience. In this case, with the fact that there are so many modifications, and the additional fact that no room is dependent upon any one inlet, since windows, crevices, and even bricks admit much air, the statement of test most relied upon is that of Parkes and De Chaumont, which is, that the amount of air required for any occupied room is the amount needed to keep the room free from any perceptible odor to a person entering it from the outer air, and to keep the percentage of carbonic acid (carbon dioxide) as near as possible to the normal rates of four parts in 10,000, and never beyond seven parts in 10,000.

14. The sensation of uneasiness produced by breathing impure air is an indication of the injurious effects that result from it, which is too often neglected. When the air is not sufficiently pure to effect the complete decarbonization of the blood, we have already seen that the result is the circulation of venous blood through the brain; the respiration then becomes impeded, and the nervous system deranged; the extent of these effects, of course, varying with the amount of the exciting cause, and with the peculiar constitutions of the individuals exposed to their influence. Dr. Harwood remarks on this subject, "The want of wholesome air, however, does not manifest itself on the system so unequivocally, or imperatively; no urgent

sensation being produced, like that of hunger, and hence the greater danger of mistaking its indications. The effects of its absence are only slowly and insidiously produced; and thus, too frequently, are overlooked until the constitution is generally impaired, and the body equally enfeebled."

15. **Ventilation** is generally spoken of as either **natural** or **artificial.** It is called natural when there are no special appliances for the admission or removal of air. It depends upon the difference in the specific gravities of warm or cold air. Of this character is that ventilation which takes place through the porous walls of buildings, through cracks and crevices, and through windows and doors which may be opened and closed. Where there is a chimney with opening into the room it also is spoken of as a natural mode of ventilation, although its capacity in this respect will vary much with the temperature of the column of air it contains.

The incidental and by no means unimportant ventilation afforded by stoves and by grates, or fireplace fires, are also generally included in natural ventilation, since they are not specially arranged for that purpose. They not only are fed by the air drawn to them, which thus makes a vacuum to be filled by incoming air, but they have much to do with the interchange of currents in the room. Besides the air thus drawn in for combustion, in fireplaces, much air escapes above the fire, and in many stoves upper openings draw out much of the air of the room. Stoves with good draught thus receive air from the room, and by directly connecting with the chimney serve as ventilators.

It is to be borne in mind, that rooms which have their heating apparatus within them are much more likely to be ventilated in this way than those into which heated air is introduced. For rooms heated in the latter way do not make draught of air to the same extent as does a heating center within the room, and do not, like the stove or fireplace, provide an exit for air.

16. Where natural ventilation alone is depended upon, the thermometer, and the sensations of individuals, are the chief guide, as to the purity and comfort of the air. Too often, however, the inmates become used even to foul air, and it is wise to test it by the sensations of those coming in from out-of-doors.

In this method of **ventilation** the chief question, so far as the entrance of air is concerned, is how to prevent draught. We have already alluded to some of the methods in use. Various other methods are devised, which may be divided into **three classes**, viz. those which by means of small holes, or gauze, or screens, or holes as in wainscoting, seek to let in the air through many small apertures, instead of a single one; those which introduce it through double sashes, or bent tubes, or elbows, so that it shall not come in by direct current, and shall, perhaps, get a little warmed in the entrance, and those which, as in the so-called Tobin system, or by perforated brick and valves, introduce it above the heads of persons so that it shall first mingle with the upper air of the room. All of these admit of some method by which the air can be shut off if the room is too cool.

17. In all the methods of **natural ventilation,** it is

generally assumed that there will be such interchange of currents that foul air will get out of the room by natural methods. Occasionally, this is aided by placing some form of valve in the side of a chimney, or some form of ventilator near the ceiling, with the idea that the foul air will ascend with the heat, and find readier exit there. Such openings often let out smoke or become wholly or partly shut by soot. While with few persons in a room, and good housekeeping and good judgment on the part of the occupants, such methods of ventilation may answer for a time, they are evidently not adapted to rooms where there are many persons, or where the heat is derived from outside sources. It is to be borne in mind that foul air is **heavier** than pure air at the same temperature, and also that warm air being **rarefied** does not, with each breath, give so much oxygen to the lungs as cold air.

18. **Artificial** ventilation is where some mechanical means are used either for the admission or removal of air or for both.

It is also not uncommon to have artificial methods for the ingress of air with no artificial methods for its egress, or to have artificial methods of egress, trusting to natural methods for its introduction.

When fresh air is introduced into the room by some mechanical force, it is usually spoken of as the **plenum** method, as when, for instance, a bellows or **fan** introduces cold or warm, fresh air into the room.

When, on the other hand, air is drawn out of a room by some mechanical force, it is known as the **exhaust**, suction, or **vacuum** method.

In some buildings both are used; in others, one or

the other only is used, it being claimed that if you drive in air, the impure air will find its way out, or if you pull out air, other air will find its way in. In either or all of these plans, we need to bear in mind that the law of diffusion of air and of gases is not dependent upon the specific gravity or temperature, although these effect some modification. All gases tend to diffuse **horizontally.**

Air laden with organic particles, even if warm, tends to cool as it reaches **walls,** and to flow down their surfaces and settle, or find exit near the floor. It is not safe to form all our plans upon the basis that the air as it comes from the lungs is warm, or that carbonic acid is heavier than pure air, or that heated air ascends and cool air falls. In practice, and in the interchange of currents amid numbers of people, there are variations from this rule, which need both the tests and judgment of experts and the experience of close observers.

19. The reasons which in some cases decide for introducing the fresh warm air at the top of the room, and in other cases at the bottom, are well presented by two good authorities. Prof. Huxley states the first view thus:—

"If there is little or no interference with outside currents, the air within the building may readily be made to move in a body from above downward, and the rapidity of its movement can be easily regulated. It may be objected to this downward movement, that the natural tendency of impurities is upward with the course of the warmer air, and that, by being made to take a downward direction, they are brought back again to be reinhaled. If it were

true that the impurities as such **immediately** rose to the ceiling and escaped from the apartment, the objection would hold; but this is not the case. On the contrary, it is known that the carbonic acid and other gaseous impurities are equally diffused, and the weight of the organic substances and other suspended matters leads to the inference that they would gravitate toward the floor, particularly when rising currents of warm air are excluded, as they should be, by introducing it at the top of the room. In no other way can so steady and equable a movement be obtained as by introducing the warm air at the top, and removing it below; and, apart from any theoretical considerations, it is found to yield excellent practical results."

20. This view, however, while in the main correct, does not decide that, with proper adjustment of inside arrangements and the introduction of warmed air, it may not be better, in other cases, to introduce the air from below. D. B. Dick speaks of another method, thus: —

"Before we can arrive at a definite conclusion, we must consider what becomes of the **cold air** that will find its way in, in spite of our efforts to keep it out. Little streams of it will flow in under the doors, trickle down the face of the outside walls, and especially from the windows, also from all the chinks that ought to be air-tight, but are not. But, wherever they come from, they will all settle in a layer on the floor. The thermometer proves this, while our cold feet corroborate its evidence. Even the cat shows its knowledge of the fact by getting up on the chair to get out of it, or deserting her soft rug on the floor to sleep on the bare top of the kitchen table.

"The **warm air** being admitted at the floor will warm

some of the cold air there, losing some of its own heat in doing so; then in its ascent to the ceiling it will carry with it the vitiated air and the watery vapor, with its organic impurities, and if the outlet is at the ceiling, it will sweep them both out of the room, without giving them a chance to cool and fall down again among the pure air. Although it is desirable that there should be a number of **separate inlets,** it is better to have only one **outlet,** because if the suction should be greater in one than the other it might draw against it, and then the flow of air would be from one outlet to the other, instead of from the inlets to the outlets."

21. As in many other cases, it is easy to announce the principle, and easy, afterward, for the architect and the sanitary engineer to determine in any given house or room the method best adapted. But to give a rule or dicta, inflexible and applicable to all cases, is not so easy. So much depends on variations, most of which are controllable, some of which are difficult of control, that we must not too readily conclude that we can apply just the same method in every case.

Although the introduction of the fresh air above has often been successfully adopted, yet such results as that of the Grand Opera House at Vienna, and the Fifth Avenue Presbyterian Church of New York, show how the method of introduction of warmed pure air from below is successful. It is also admitted to be more economical. More depends upon the locality and number of the entering points than upon proximity to floor or ceiling.

For the removal of foul air, it is now generally believed that openings near the floor are more useful than those at the ceiling, although in large assembly-rooms both are desirable.

22. The whole subject has been well stated by Dr. J. S. Billings, in his recent work on *Ventilation and Heating*, from which we abbreviate the following outline: —

"*First.* The register must be in such a position, and of such a size, that the requisite amount of air can be introduced through it without causing currents of air of such velocity as will cause discomfort to the occupants of the room. The only difficulty in this respect occurs in rooms occupied by a number of persons, such as assembly and school rooms, churches, theaters, hospitals, etc. Under such circumstances, it is sometimes very difficult to so locate the FRESH-AIR registers that the currents therefrom will not be unpleasantly perceptible if they are rapid, and it then becomes necessary to make these registers of such an area that the velocity of the inflowing air need not exceed one and a half feet per second to secure the introduction of an amount sufficient for both warming and ventilation. When the registers are so situated that the currents from them will produce no discomfort, they may be made smaller. For example, if it be determined to introduce the FRESH AIR directly through a perforated floor in an assembly-room, the total area of openings should be at least one hundred square inches for each occupant, while the area of register openings need not be more than forty square inches for each occupant, if they are placed near the ceiling.

"*Second.* Taking it for granted that the FRESH AIR is to be warmed in cold weather before it is brought into the room, its registers must not be placed below the foul-air registers, unless the former are scattered near the floor of the room. The reason for this is, that direct currents between the inflow and outflow registers are easily established when the latter are above the former, and in such

case little change is effected in the great mass of the air in the room.

"*Third.* Flues of proper size cannot usually be placed in thin walls, such as ordinary interior partitions. A flue measuring less than five inches in its smallest diameter is of little use. Fortunately, in ordinary dwelling-houses, where this difficulty of thin partition walls is greatest, the precise location of FRESH-AIR and FOUL-AIR flues is of minor importance, so long as the precaution advised in the preceding section be observed.

"*Fourth.* Fresh-air registers should not be placed in a floor so as to be flush with its surface, because dust and dirt will fall into the flues and be returned, to a certain extent, in the column of ascending air. Such registers are also a fruitful source of loss of small articles. It is always possible to continue the flue upward into a step or seat, and then place the register in the side of this.

"There is less objection to placing foul-air registers in the floor; but even this should be avoided, unless the openings are covered by some article of furniture, as, for instance, in a hospital ward, where a good position for the foul-air registers is in the floor beneath each bed; and even then the register should not be flush with the floor, but rise an inch or two above its surface.

23. "*Fifth.* In dwelling-houses and buildings of moderate size, it is economical to centralize the heating apparatus as much as possible, keeping the fresh-air flues in inner walls; but it is not easy by this method to secure sufficient warmth in the vicinity of windows, especially on the side most exposed to the winter winds.

"On the other hand, hot-air flues should not be placed in outer walls, unless these are thick and substantial, and even then it will be good economy to make the flue of terracotta or galvanized iron, so set as to leave an air-space of

an inch or two on the other side. For rooms on the floor immediately above the radiators, it is not necessary to place flues in the walls in order to bring the registers under or near the windows, which is their best place, so far as heating is concerned. Foul-air flues should not be placed in outer walls, unless they are to be carried downward and to have some means of aspiration connected with them.

"*Sixth.* General Morin, and the majority of modern French engineers, advise that the place of introduction of fresh air shall be near the ceiling, in order to avoid unpleasant currents, while the discharge openings, on the contrary, should be near the floor. The introduction of warm air near the ceiling, in order to prevent disagreeable currents, is not absolutely essential, for such currents can be avoided, as above explained, by making the registers of proper size; and to secure comfort in cold weather, it is necessary, on this plan, that the air shall be introduced at a temperature several degrees higher than is required if it be admitted at a lower level.

"The proper position of the foul-air registers depends on the purpose of the room and on the season. During cold weather, in the majority of cases, they should be near the level of the floor, to secure a satisfactory distribution of the air with the least expense. In large assembly-halls, however, and especially where it is desired to provide for respiration, air as pure as possible, instead of foul-air diluted to a certain standard, the discharge-openings should be above.

"*Seventh.* In order to secure a thorough distribution of the incoming air, it is usually recommended that the discharge-openings should be in the side of the room opposite to that in which the fresh-air openings are placed, and as far as possible from them.

"In all dwelling-houses, however, and in rooms not having windows on opposite sides nor containing a sufficient

number of occupants to exercise any special influence on the temperature, good ventilation will be secured by placing the fresh warm-air openings on an inner wall, and the discharge-openings in the same wall at the same or a lower level. This is the arrangement in most dwellings heated by indirect radiation, the fresh-air register being in the side of the chimney near the floor, and the foul-air passing out through perforated fireboards on the same level a few feet away. The result is the establishment of a circulation from the fresh-air opening upward and along the ceiling to the outer walls and windows, thence down the wall to the floor, and along the floor to the discharge.

"But when we come to deal with rooms having a large floor area in proportion to the height, and containing fifty or more persons, whose **heat production** is a factor that must be taken into consideration, there is some danger by this method that there will be an unsatisfactory distribution of the fresh air when the temperature of the external air is not below 50° F."

24. Where the method is that form of indirect heating in which a room is kept warm by radiators or pipes which receive their heat from apparatus outside the rooms which does not introduce any new air with the heat, we are always to bear in mind that, although the heating does not consume the oxygen of the air in the room, it does not provide any means of escape for foul air. So, practically, such rooms, if occupied by many persons, greatly need good artificial arrangements for ventilation.

Where some form of **flue** is relied upon for ventilation, the following points are to be borne in mind. No flue can be considered complete unless it has a caliber of eight

inches in diameter, is smooth internally, and unless, by some means, a pretty uniform temperature up to about 65° can be secured in it. Ventilating-pipes connected with it should also be smooth, and angles should be avoided as far as possible. Not enough allowance is made for the effect of angles on friction, and for the adhesion of air to surfaces. Many holes that are called ventilators, the anenometer and other methods of test show to be very deficient in draught, and so of little service. The draught is sometimes aided by **cowls** or other fixtures attached to the top of the chimney or duct, varying with the wind, and aiding the outward current.

25. The testing of the purity of the air is a matter of importance, and yet so much a chemical and biological investigation as to be at the command of those unskilled in methods, to only a small extent. The test afforded by the sensations of those coming into rooms out of pure air is of considerable value, as the unblunted senses are themselves instruments of test.

What is known as the **Angus Smith method** is quite available. It is based on the fact that the amount of carbonic acid present in air is an approximate test of its purity or impurity, and that we are able to get an ocular sign of this by the use of lime-water.

Dr. Lincoln, of Boston, has found the following test available. A series of bottles of known size are chosen, graded from large to small, and fitted in a wooden frame. The whole apparatus is carried to the room to be tested. The bottles have been previously filled with water, and when inverted the air fills them at once. They are stoppered and carried to the laboratory, where a given amount (say one-half ounce) of lime-water is introduced

into each, and also a few drops of a solution of phenolphthalein, which gives a rose color to the lime-water. By long shaking of the bottles, the carbonic acid present is neutralized, and the color fades. The largest bottle that shows a complete change affords a comparison by which we may reckon the amount of carbonic acid gas present.

What is known as the **Wolpert test** is a convenient form of apparatus in which, by means of a graduated glass tube containing some lime-water, and another glass tube with a rubber bulb, the air of the room is squeezed into the lime-water, and the number of compressions with the hand necessary to cloud the lime-water, quite accurately determines the amount of carbonic acid present.

26. In connection with the subject of heating and ventilation the mode of **lighting** needs some consideration. The effect of sunlight is conservative of health, although it may so be reflected in rooms as to cause excess of heat, to which ventilation must be adjusted. The electric light has the advantage over all other artificial lights, in that it does not consume the oxygen from the atmosphere or add to it carbonic acid gas. It is also free of dust and of other gases which are apt to be mingled with other forms of lighting.

All other forms of light used are damaging to the purity of air, chiefly as they exhaust oxygen and add carbon dioxide. But they vary considerably as to the amount of smoke, imperfect combustion, and of dust and gases. So much heat is evolved from a common kerosene lamp, for instance, that the currents it causes are also to be considered. Some of the lamps which are arranged for use without chimneys also contaminate the air by imperfect combustion.

27. In the use of gas, as a matter of self-protection, consumers should occasionally test the quality of the gas. Gas employees, in certain parts of their work, often suffer from catarrh, bronchitis, and phthisis. This is in part due to the ammonia, carbonic acid, sulphureted hydrogen, and other gases evolved. The purifiers, condensers, and washers seek to remove these, and do it quite effectually when the apparatus is in good order and skillfully used. Gas cannot be used in a conservatory unless the products of combustion are fully removed. It is impossible to remove the sulphur entirely from gas. The English law prescribes that there shall be no sulphureted hydrogen in the gas as delivered, and that other forms of sulphur combination shall not exceed twenty-five grains per one hundred cubic feet.

28. Lights have, by their heat, been largely utilized for making a draught that will carry foul air out of rooms. To this end, chandeliers often have air-ducts above them communicating with the roof. While these are not quite so effective as they seem to be, and do not generally make a current that reaches to the sides and corners of the room, they nevertheless aid somewhat in an upward draught. There are now instruments of precision by which it is possible to determine where and how to fix and locate foul air-ducts, as also to determine the velocity of movement of the air in them.

29. Gas, as made by the iron process, consists chiefly of hydrogen .40 to .50 parts, marsh-gas .35 to .45, carbonic oxide .045 to .075, olefiant gas and other hydrocarbons .04 to .08, and usually very small amounts of carbonic acid and air.

Gas made from petroleum contains no sulphur or ammonia.

Water-gas, as it is called, is made by passing steam over incandescent red-hot carbon, the product being a mixture of hydrogen and carbonic oxide. This non-luminous gas is then made luminant by the combination with it of gas from petroleum, naphtha, or cannel-coal. It contains, as a rule, about 50 per cent of hydrogen, 40 per cent of carbonic oxide, and 10 per cent of petroleum or naphtha gas.

It is now claimed by many companies that the carbonic oxide, which is so injurious, is reduced so that it is equal in purity to the gas produced by other processes. There is need, we believe, of a constant watchfulness among consumers, to have the quality of the gas furnished tested from time to time.

30. Escape of gas by reason of imperfect gas-fixtures is to be carefully guarded against. The Brooklyn report of 1883 shows that many lose their lives, or are partially suffocated thereby. Many more suffer a general deterioration of health.

Various forms of gas-burners are now in the market, some of which, no doubt, save the consumption of gas. They are all to be tested as to whether they interfere with combustion.

Electricity will no doubt ere long be made available to the student and to homes for lighting purposes. In the great advantage that it does not consume the oxygen of the air, and has no deleterious gases, it commends itself as one of the aids to securing greater purity of air. It needs to be tested more fully as to the effect of the light on the eyes, and as to what shading is

needed. It is well adapted for large assembly-rooms, and will aid much in preventing that stifling sensation too often experienced where large evening audiences are assembled.

It is thus apparent that the whole subject of artificial lighting needs to be recognized as related to the contamination of air or the reduction of its oxygen, as also to some extent as affecting modes of heating.

CHAPTER XVI.

THE SCHOOL AND ITS APPOINTMENTS.

WHILE it is recognized that it is not always possible to secure the very best sites or buildings for schools, it is always desirable to have a perfect ideal as a standard of comparison, and to secure the nearest approach thereto.

First of all, it is important to secure ample grounds around the building. This is not only desirable for play and recreation space, but because buildings closely adjoining, by interference with light and ventilation, and by noise, smoke, or other inconvenience, detract from the completeness of the building for its purpose. The frontage of the building depends somewhat on locality and direction of winds. Effort should be made so to arrange it as to give to each room some sunlight on pleasant days. As a rule this is best accomplished by having the corners of the building in the direction of the four cardinal points.

2. The choice and preparation of the ground for the building must also have special reference to the securing of a dry, well-drained area. The water-level in the soil should never be higher than seven feet from the surface. Ground that is compact, like clay, must be so thoroughly underdrained as to give a cellar that will be dry, and a playground from which water will quickly disappear. The building should be so provided with

rain-leaders as that the water from the roof will not fall upon the lot, but be carried off to the street or other convenient place. It is usually best to have the cellar or basement partly above the ground level, so that it may have windows which will not need to be in part below the surface.

Where the entire structure is to be of stone or brick, it is best to have a damp course, just above the ground level, either of slate or asphalt, so that there may be no conveyance of any possible dampness to the upper walls. With a view to proper aeration or equability of temperature, wooden school-houses should be inlaid with brick.

3. Entries and stairs must always be wide. The stairs should never be spiral, but have platforms or landings instead of long flights. The steps should be of good width and easy rise. The best width is generally not less than 12 or more than 18 inches, and the rise not less than 4 or more than 6 inches. The French rule is as follows: "As, on the average, human beings move horizontally 2 feet in a stride, and as the labor of rising vertically is twice that of moving horizontally, the width of the tread added to twice the height of the rise should be equal to 2 feet. Thus, if the rise be 6 inches, the tread should be 12 inches. For children, the width of the tread should be a little less. Doors must always open outward. Double stairs or fire-escapes are often needed as a precaution. School-rooms should never be higher than the second story above the basement."

Ceilings less than ten feet in height and over twelve are not desirable. A greater height than twelve feet adds to the number of stair-steps and gives no valuable aid to ventilation.

The first great effort should be to keep dampness and dust out of school-rooms. To this end, all over-clothing must be well provided for in rooms outside of the school-rooms. The narrow stall system, in which each pupil may leave all outer garments, rubber-shoes, umbrellas, etc., is desirable, and not expensive, if space is well utilized.

4. It is seldom advisable to have more than 50 scholars in one room. With a floor-space of 25 feet for each scholar, this would give 1,250 feet of floor. A room 25 by 50 or 30 by 40 is better than a square. For class-rooms alternately occupied, a floor-space of 15 feet will answer. It is very important that the floor be of such material, and so oiled or polished, and so joined, as that dust shall not lodge in crevices. For the same reason, all beaded mouldings on doors or windows are to be avoided. Every particle of dust kept out of a school-room, and every crevice avoided, is so much gain for the air of the room. The greatest difficulty as to desks or seats fastened to the floor is that they serve as catching-places for organic particles. In all well-ordered schools, at the spring and fall room-cleaning, they are unscrewed and removed so as to admit of thorough cleansing of floors. The desks and all shelves need thorough scrubbing. As a rule, wainscoting for school-rooms is better than the base-board, if only the seasoning and joining are such as to present one even surface, easily kept cleansed and dusted. Above this, whitewashed walls are best for crowded schools, since a coat of whitewash each month will do much for the purity of the air. Where other walls are had, they should be of the hardest and smoothest finish.

5. Where, for any reason, light from the sides or rear cannot be commanded, light from above is much better

than light from below the level of the pupil's head. Light from above is shaded by the eyebrows, eyelids, and eyelashes, and often by head-coverings, so that we can more easily adjust ourselves to the excess. Light from below, especially from white and polished surfaces, will soon tire the vision. Single, quarter-round cornices should take the place of any network adornments. Rounded corners are now preferred wherever they can be made.

White walls are not so favorable to many eyes as light blue. Light in which the blue element is in excess, although not to the exclusion of all others, is by most persons felt to be soothing and grateful. Gray and light green are also good colors. After the discovery by Newton of the compound character of light, it was soon found that the harmonious and pleasing combinations were those in which the colors are **complementary**, that is, in which they would make up white light if blended together.

The window-space in school-rooms should not be less than one-fifth of the floor-space. The panes of glass should be large, so that series of cross-bars will not intercept the light. As it should not come from below the level of the pupil, while sitting, they should be not less than four feet from the floor. The windows both for light and ventilation should extend nearly to the ceiling. Light from the rear is much better than from the front. Light from the left side is to be preferred to light from the right, since we read and write from left to right, and the arm and hand do not obstruct it. If window-shades are used they should be of colors similar to the wall, and should only be used to keep out sunlight or very excessive light. There should be a

passage-way between the windows and the desk, and no desk should be so far from a window, or so situated as to other occupied desks, as to much diminish or intercept the light.

There should be transom or tilting windows over the doors.

6. The location of blackboards in the room is important. These should be so placed that the pupil will not have to face the light, but receive it from the left side or the rear. Great care should be taken that blackboards are in excellent order, so that marks upon them can be distinctly seen. The scholar should have no embarrassment in work of this kind. Letters or figures on boards, when well made and full two inches in height, cannot be seen over thirty feet.

7. Seats should be single if possible, and desks should be adjusted to the size of the scholars. The front of the desk should be perpendicular to the edge of the seat, and the position will be a convenient one if the desk is so arranged as to admit of partial folding, or change of angle. In writing, the paper should be raised to an angle of 20°; for reading, it is better raised to an angle of 40°; but if not adjustable, 30° will answer. The relation of the seat to the desk should be such that the book may be from 12 to 16 inches from the eyes when the scholar sits erect. The shelf beneath the desk should be movable so that it can be taken out, at the direction of the teacher for examination. The socket for the inkstand should be open, so that any dust may fall through.

A good rule as to the relative height of seats and desks is, that the desks should be of such a height

that the elbows may rest upon them when the body is erect without any displacement of the shoulders. It is not to be forgotten that the physical system is pliable during the period of school life. Bones and cartilages, as well as softer tissue, yield to continued pressure, and become permanently set in a wrong way. Many injuries to the spinal column, to the chest, to the eyes, occur in school life. The heating and ventilation of rooms are treated in a separate chapter, and serve as directions for schools.

8. No perfection of a school-room will take the place of excellent janitorship, which means thorough house-keeping. The arguments for sweeping and dusting and airing occupied rooms in the house each day are multiplied more than tenfold when we come to deal with a school. Scrubbing of floors, dry and sometimes wet rubbing of paint and of walls, washing of furniture, and all the details of the very best room-keeping, must be sedulously attended to. It is not only a part of health and comfort, but of the true education. It aids much in the training of the children to correct habits as well as in the securing of better health. Thorough airing should always take place immediately after the dismissal of the scholars.

9. Spitting on the floor should always be an offence, and all the more since we have come to know that the dried *sputa* of whooping-cough, diphtheria, and of other diseases can impart the contagion. A single spittoon in each room should be provided for an absolute necessity. There should be a waste-basket in each school-room, so that nothing may be thrown upon the floor. These are not mere niceties, but have to

do with discipline and health. Each school needs to be provided with wash-basins, soap, and towels. Clean hands, a clean face, and a pocket-comb help on the true education.

The school life should not prove any risk to health, but should have the preservation or improvement of health as one of its educational designs. Calisthenics and gymnastics, as already referred to, aid much in securing pure air and right development.

10. It is recognized that many nervous diseases have their origin in school-life. A good authority has said that in its ultimate analysis education is a training of the nervous system. Perfect health and rhythm of the nervous system has very much to do with vigor, self-control, self-reliance, right habits, and success. It is a mastery that is to be studied and trained for. Overwork, spasmodic work, cramming spells, mental pressure, without physical exercise and recreation, are the causes of debility, headache, irritability, sleeplessness, dyspepsia, and nervousness in all its protean forms. Slight attacks of any spasmodic disease, by the law of imitation, are apt to incline others of mobile temperament to similar disturbance of self-control.

Such symptoms must very early attract the attention of teachers during the period of school life. We should never wait for spasm or lesser irregularities of nervous and muscular action, or for that general want of tone which too often proclaims an impending break-down or wreck of that which is the most intricate and sensitive of all vital structure. Nay, we should see to it that there is such well-planned and well-executed education of all that relates to bodily development as

shall preclude the possibility of the mind being educated at the expense of the body. There is a hygiene of the mental as well as of the physical. They are so interwoven, that they train with poor judgment and worthless hands who seek to guide or handle the one without the other.

11. While the diseases of schools are not peculiar to school life, yet some of the communicable diseases are so fostered by or spread from our schools as to need special caution.

The impure breath and the soiled skin are the two first great sources of a minor class of transferable diseases. Thus it is not uncommon for parasitic diseases, such as those of the scalp or some form of skin irritation, to be conveyed by those who are not cleanly in their habits, or who have contracted them from uncleanly sources.

Even common sore throats are sometimes communicable, and unclean mouths and foul breaths should be prevented by the free use of water for rinsing, and by cautions in special cases. The teacher by general statements as to the relation of foul breath to bad air and disease can often inculcate the spirit of cleanliness.

Inflamed or sore eyes we have occasion to notice elsewhere. But it cannot be too plainly impressed that sore-eyed children should not attend school unless some physician has vouched for the mild and non-communicable character of the malady.

12. Among the usual contagious diseases, measles, whooping-cough, and mumps are very frequently aided into epidemic prevalence by the schools. As a rule it is generally not considered necessary entirely to suspend

school on account of them. Yet measles is often a serious disease, and especially as leaving the lungs susceptible to the inroads of bronchitis and consumption in later years. All parents should be advised to keep children who have had measles out of school until the cough has entirely ceased.

Small-pox is so well recognized as a fearful invasion, that we only need to refer to the fact that vaccination should be universal.

Diphtheria has come to be so frequent and insidious a disease, that teachers, school officers, and parents should exercise the utmost care. Children should not be sent to school, from families where diphtheria is, until there is consent of the physician. The same is true as to scarlet-fever. The only way to prevent entire suspension of schools for a time is to prevent these diseases from spreading by the exercise of due precaution.

CHAPTER XVII.

WHAT TO DO WITH REFUSE, OR CAST-OFF MATERIAL.

LIFE is made up of construction, waste, and repair. It is so arranged that in the very processes of life, as well as in the incidents of living, there is a constant production of what is variously called excretion, refuse, or offalling. It consists of materials which are organic, and so are changed by the various processes of decomposition.

In addition to these, all organic nature about us is undergoing the same process. The material cast off is not at first, as a rule, hazardous to health. But if by retention or accumulation in quantity, decomposition goes on amid the living where there is not enough air to dilute and neutralize it or convey it away, or where there is not enough vegetation to appropriate it, it is left to taint the air, to pollute the water and the soil, and so to cause the perils of disease to animals, and especially to mankind.

It therefore becomes necessary for us to understand that such material is not to be allowed to accumulate in and about human dwellings, but is to be disposed of by those methods which the various processes of nature indicate.

2. One of the most radical of these is **combustion.** The description of the Gehenna outside of Jerusalem is that of a constant fire into which was thrown every-

thing of a decayable nature, in order that it might be burned up. This plan has been adopted in some cities, especially in times of pestilence. It is claimed, with truth, that thus all refuse material is put beyond the risk of causing harm. The only question is, whether there are not other plans as available, and on other grounds to be commended. Inasmuch as in the arrangements of nature, such material is quickly appropriated and transformed without risk, the chief point seems to be, not to interrupt natural processes, or so arrange that they may take place where there can be no risk to health or life. Nature employs other forms of combustion besides fire.

As to human secretions and excretions, a part is easily and readily disposed of in the usual methods of frequent bathing and ablutions. Water serves as a carrier and remover, and both air and moisture help to transform them into materials for plant-life.

3. There is no rotation or conservation in nature more beautiful than that which relates to the relations of plant and animal life. Whatever is not so readily or rapidly disposed of only needs to be carried away to be mingled with earth in order that vegetation may fully appropriate it, and not leave any part for human inhalation.

As a rule, nature allows a brief time in which such refuse is not dangerous, but at the same time forbids its storage in any form within human habitation, or where human beings congregate. Cesspools, garbage-heaps, middens, slop-holes, and all provisions for the accumulation of any such material amid the schools or the homes of the people, are to be regarded as haz-

ardous. The only limitation to this statement is in the fact, that if such materials are mingled with the ground in only such quantities as it and its vegetation can dispose of, or is kept dry, or kept away from any heat or moisture, it will not undergo these dangerous decompositions.

4. But because there is so much of moisture in the air and the earth, and because the heat so often ranges high, and reaches even to depths in the ground, it is not safe to adopt, as a system, the STORAGE of any decayable, fermentable, or putrescible material. It has too often happened that what has been found for a long time to produce apparently no bad results, suddenly takes on that kind of change which either deteriorates or poisons the air or water, and so causes general ill-health or specific and dangerous maladies.

Hence there is the one uniform rule as to all inhabited places, that such matter should not accumulate, or if there are arrangements for temporary storage, there should be such kind of storage, and such timely and orderly removal, as will greatly reduce the risk. It is also to be remembered, that, where there are light and heat and air, and open ventilation, as in the compost-heat in the barn-yard, nature often conducts such processes without any peril, whereas similar decomposition taking place in heated cesspools or in accumulated varieties of mingled refuse, may cause the greatest disturbance.

5. It is also more perilous because such underground accumulations are reached by the varying water-level in the ground. So when heavy rains come, or when the earth has been kept wet by absence of sun and

air, the little rills of ground-water carry polluted matter into the wells, there to mingle with the potable water-supply. It is known that many a case of fever or flux occurs from this cause.

The opposite of this sometimes occurs in some soils or ground structure. The wells have been kept full, and the material at the distance has been kept covered with water. But a sudden and prolonged drought lowers the well-water, and so the well becomes the drain for a greater area. This polluted water is drawn off toward the well, while the uncovered mass is left to hasten to more rapid decomposition because of the heat and partial dryness.

6. Too often the bad art of man interrupts and overcomes this conservatism of nature. Sometimes the results are merely such pollution of air, or such deterioration of water, as only causes a family or an individual to be less healthy, and to be complaining of various departures from a feeling of real wellness. Some, with good vital force, become adjusted to the condition because of their natural vigor, while others go into some form of ill-health. Occasionally the result is, to a whole community, a specific epidemic like typhoid fever.

We have an analogue to this in typhus fever, where filthy houses, filthy yards, and filthy living induce the typhus, ship, or jail fever, which consumes multitudes, and provides a contagion that seizes upon those who live amid healthy surroundings.

7. It is not necessary to specify all the various forms of accumulation, or the various methods by which cast-off materials are retained in close proximity or not

disposed of in a safe way. It is enough to know that **cleanliness** means, not merely neatness, but such management of person and things, of self and surroundings, of food and of clothing, of heat and air, of soil and dwelling, of school-house and grounds, as will cause all refuse, all decayable or organic matter, to be disposed of in such a way as not to imperil health. In doing this we may only have to let natural processes have their way, or to imitate them. In other cases, we have so far changed natural conditions as to need to make compensation by artificial methods.

Thus, while, in general, the use of fire, earth, air, and water are sufficient to take care of such products, sometimes we need to call into use some special disinfectant, as chloride of lime, to destroy the exciting cause, or as sulphate of iron, to interrupt its progress, or plaster or charcoal, to absorb its results, and thus to deliver animal life from its dangers.

8. It is far more important to appreciate the principle here involved, than it is, in this connection, to give all the details by which it is to be accomplished. Personal cleanliness and perfect housekeeping are the beginnings. The watchfulness of prevention will much limit the accumulation of very many decayable matters. The fire will dispose of very much of dry refuse. In the structural arrangements, which are made for the less easily disposable matters, the necessity of a proper method will be so felt that the careful householder will see to it that satisfactory arrangements are made, and that proper administration is exercised. No matters of science and art have been more fully studied, and safe methods will not fail to come to the notice

of those who understand the possible and too often actual evils from accumulations of refuse.

9. Where, on account of odors, or the suspicion of foul accumulations or dangerous pipes or sewers, **disinfectants** are needed, the following will be found convenient.

Draughts of air may be used for all floating foulness; dry rubbing for all easily detached foulness; wiping and water scrubbing for all attached foulness.

Hot air. Clothing or bedding is cleansed by being put in a furnace of dry heat of from 230° to 300° F. It should be subjected to the heat for about one hour.

Hot water. Very hot or boiling water is applicable to the cleansing of all garments, utensils, etc., admitting of such a method. Put them in when the water is quite hot, and allow it to come to the boiling-point. Where garments have been soiled, it is well to throw them first into a tub containing a disinfectant solution, and from it transfer them to the hot water. If too soiled for renovation, they should be destroyed by fire.

To disinfect a room or building, so needing disinfection that its contents and surfaces cannot be easily dealt with singly, close the room or building, its windows, doors, and chimneys, so as to exclude the outer air as far as possible. Break roll-sulphur in small pieces, place it on an iron plate or other metallic dish, and set this on a pair of tongs, or other crossbar, over an iron pot in which there is water, or over a large box of sand, so as to avoid danger of fire from small particles of burning sulphur. Light it by a few hot coals, or some alcohol poured around the sulphur and lighted. Then leave, and shut the door after you.

Three pounds of sulphur is sufficient for 1,000 cubic feet of space. The sulphur will convert all the oxygen of the air into sulphurous acid, and all organic particles are likely to be changed. Keep the room closed three hours after the burning has ceased, and then air well four hours before occupying. Clothing and bedding needing disinfection may be hung on lines and left in the room. Most furniture is not permanently injured, but needs dry wiping, and then washing off afterwards.

10. **Chloride of lime** is a valuable disinfectant, chiefly because it contains from 25 to 30 per cent of chlorine, which is liberated under proper methods of use. It needs slight moistening, frequent stirring, and sometimes the addition of an acid, as vinegar or common spirits of salt. The test of its efficiency is that the odor of it be kept constantly perceptible.

One-half pound of it to a gallon of soft water is good for cleansing utensils, sinks, water-closets, drains, etc. One ounce to a gallon of water suffices for linen, which must not be left long in the solution, but be wrung out in fresh water. During an epidemic, sprinkle dry chloride of lime over contents of vaults, sinks, and cesspools, etc., daily.

Solution of chlorinated soda, usually known as Labarraque's solution, is a convenient liquid preparation, valuable for use in saucers in the sick-room, or in utensils. Its odor should be perceptible to any person entering the room.

The chlorides are not to be used with carbolic acid.

Sulphate of iron (copperas) when used is dissolved in water in the proportion of one and a half pounds to a gallon of water, for soil, sewers, etc.

Sulphate of zinc and common salt, dissolved together in water, in the proportion of four ounces of sulphate and two ounces of salt to the gallon, are used for clothing, bed-linen, etc.

One-half pound of sulphate of iron (copperas or green vitriol), or one ounce of sulphate of zinc (white vitriol), or one ounce of sulphate of copper (blue vitriol), or one ounce chloride of zinc (butter of zinc), or one ounce of chloride of lime (bleaching-powder), put to a quart of water, answer similar purposes as disinfectants.

11. The following are also valuable.

Solution of corrosive sublimate. One ounce to eight gallons of water. It should be colored with indigo to prevent its being mistaken for pure water.

Commercial sulphuric acid. One pint to eight gallons of water.

The following, because of its mild odor, may be used by those who object to the odor of chlorine, or that of the other disinfectants.

Thymol solution. Two drams of thymol (crystals) dissolved in ten drams of alcohol, twenty drams of glycerine, and one gallon of hot water. It gives a slight pleasant odor.

Lime; **plaster**; **charcoal**; **dry earth**; **sifted ashes.** All these have value, chiefly to be tested by the rapidity with which they correct odors. Fresh-slaked lime should be scattered in all places of foul odor. It, or charcoal or plaster, may be scattered over heaps emitting foul odor. Calx-powder is made by pounding one bushel of fresh dry charcoal and two bushels of stone-lime, and mixing them, and is of great practical use.

All these substances absorb foul gases, and dry up moisture, and so help to retard decomposition, or absorb its results. Where lump-charcoal is used, it may be refitted for use by reheating it. Quick-lime and ground-plaster should not be used where they may be washed into pipes, as they form lime-soap or obstruct by hardening.

Chapter XVIII.

THE NERVOUS SYSTEM, AND ITS RELATION TO HEALTH.

HAVING studied sufficiently for hygienic purposes the bony system by which the framework is sustained, the joints by which it is made capable of motion, the muscles by which it is moved, the stomach and other apparatus by which food is received, digested, and assimilated, the blood which is the chief liquid for supply, and the heart, lungs, and vessels of circulation and distribution, we now come to inquire into the system which presides over all as a force for motion and sensation. This is known as the **nervous system.**

Dalton defines the function of the nervous system to be, "to associate the different parts of the body in such a manner that stimulus applied to one organ may excite the activity of another." It is the presiding force by which the coördination, coöperation, and rhythm of the whole machinery is secured.

2. The nervous system, although often spoken of thus by one term, has **two** great divisions.

The **first** is known both as the **cerebro-spinal system,** and the nervous system of animal life. It is made up of the brain, the spinal cord, and the cerebral and spinal nerves, and the **plexuses** or nerve-bundles connected therewith.

The **second** is known as the great **sympathetic** or **ganglionic** system. It is called by Bichat, the nervous

system of organic life, and by Dalton, the nervous system of vegetative life.

It is called the sympathetic system, because, mostly through it, all parts of the general system are brought into sympathy.

It is called **ganglionic,** not because the other system has no ganglia, but because this system so largely abounds in ganglia.

It is called the **system of organic life,** because it forms the chief plexuses about the heart and stomach, and has most to do with the action of great central organs. Its nervous centers (ganglia) are situated **anteriorly,** at the junction of the vertebræ of the spinal column, and are connected by intermediate cords or nerve-fibers. They thus form a chain alongside of the vertebral column.

It is fortunately placed mostly beyond our control, or else we might forget to keep the heart beating. Dr. John Brown, in his little book on *Health*, has, as a frontispiece, the hand of the Creator clasping the heart and regulating its motion, and beneath it the motto, "For in Him we live and move and have our being." It is this nervous system that gives to the heart its motion, and that enables life to carry on its processes.

3. The **cerebro-spinal** system begins with the cerebrum or brain, and is continued through the spinal column. The cerebrum is encased in the hard structure of bone which forms the cranium or head, and then has three coverings of membrane. The brain substance consists of **two hemispheres,** so that, in a sense, it may be called a double organ, as are the eyes, ears, etc. At the base of these there is a lobe or offset known as the **cerebellum.** It has especially to do with the rhythm or

coördination of muscular action. The degree to which this is affected in **intoxication** points to the rapid and profound impression made upon the brain. Each of these hemispheres is composed of two substances, so distinct in fact and in appearance as to have the names of **white** and **gray** nervous matter. The white nerve substance is everywhere an organ of **transmission.** It is so composed of fibers as sometimes to be called fibrous tissue, and each fiber or filament is a tubular membrane, in the interior of which is a semi-fluid matter. Then through the center of the fiber is a **gray** thread, which is known as the axis cylinder, and is probably the most essential part.

These fibers run parallel to each other, as the threads of a skein of silk, varying in size from $\frac{1}{2000}$ to $\frac{1}{12000}$ of an inch in diameter. They are smallest in the brain and spinal cord, and largest in the nerve trunks. These nerve fibers are collected in **bundles** of larger or smaller size.

4. A nerve is made up of several bundles. More or less of the fibers and branches are made by the division of these bundles into smaller ones. The **white** substance constitutes a large portion of the central part of the **cerebrum,** and of the mass near where the spinal canal starts out from the brain, and known as the **cerebellum.** The **gray** substance thus seems like a cortex or bark, covering the white or inner mass. But in the spinal cord, the white portions form the **exterior** part. The whole of the substance of nerve trunks and branches is made up of it, except as they are stiffened by some areolar tissue interwoven to give them firmness.

5. The **gray** nervous matter, which is thus the covering in the brain and the central portion in the spinal cord, is found in considerable mass at the base of the brain, as it extends to form the center of the spinal cord. It consists of cells embedded in granular matter with a kind of granular pigment which gives it the gray color. This gray matter, wherever it is found collected in any part of the system, is called a **ganglion.** These are secondary nervous centers, smaller and less complex than the brain. They are found in the cerebro-spinal system, at the posterior roots of all the spinal nerves, where they come out between the vertebræ as well as at points of nerve distribution. The **sympathetic** system is to such a degree made up of ganglia or aggregated gray matter as often to be called the ganglionic system.

6. The **spinal cord** is but the continuation of the brain, and, like it, is protected by a bony structure made up by the vertebræ with intermediate spaces between, through which nerves branch out to be distributed to the whole body.

The brain and spinal cord are so arranged that the right side of the brain is connected with the left side of the cord, and the right side of the cord with the left of the brain. It is because of this arrangement that injury to one side of the brain affects the opposite side of the body. The weight of the brain is about three pounds, and that of the spinal cord about one-thirtieth as much.

7. We next come to notice the nerves, which come from this **cerebro-spinal system.** Those known as the cranial nerves come out from the *medulla oblongata*,

which is near the cerebellum, and is the cranial portion of the spinal cord.

A process of white nerve-fiber connects the cerebrum, the cerebellum, and the medulla oblongata.

The cranial nerves succeed each other in pairs from in front backward as follows:

1st pair. **Olfactory,** or nerves of smell.
2d pair. **Optic,** or nerves of sight.

These two are almost processes or extensions of the brain, as if to bring it into direct contact with the outer world.

3. **Motores Oculi,** which as nerves of motion supply most of the muscles of the eye.

4. **Pathetic.** This, a very small nerve, supplies one of the muscles of the eye. It was called pathetic because it moves the muscle of the eye which is claimed to give it most expression.

5. **Trifacial.** This is the largest cranial nerve. It has two roots (motor and sensory) like those from the spinal canal, and like them it has a ganglion at the root of its posterior part. It is the great nerve of motion and sensation for the entire face. Some well-known affections of the muscles of the face, and local neuralgias, arise from cold or other irritation of this nerve or some of its many branches. Thus we have facial paralysis, or that painful affection known as **tic-doloreux.**

6. **Abducens.** This is a small motor nerve to one of the muscles of the eye.

7. **Facial,** also called *portio dura,* from its hard texture. It supplies some of the muscles of the face, the interior ear, and the parotid gland, and often has to do with face and ear ache.

8. **Auditory,** or *portio mollis.* It is a nerve of sensation distributed only to the middle ear.

9. **Glosso-Pharyngeal.** This is partly a nerve of taste and partly of motion to the muscles of the pharynx.

10. **The Pneumogastric,** or *par vagum.* It is called pneumogastric because so plentifully distributed to the lungs and

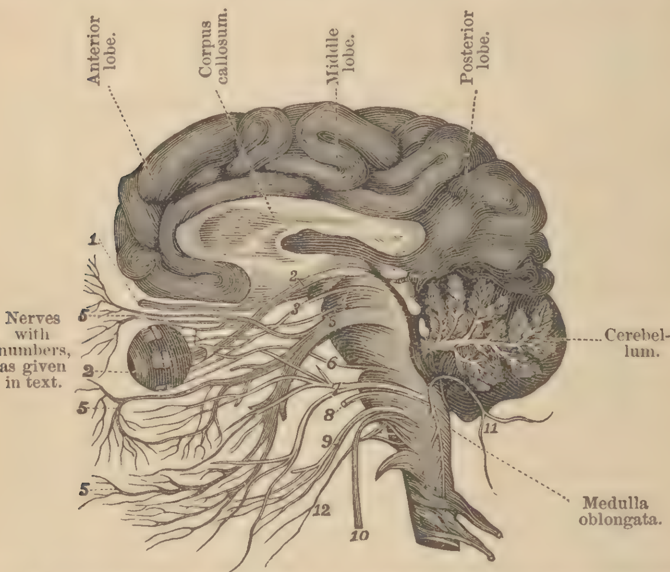


FIG. XXIV.—Right side view of Human Brain, showing Cerebral Lobes and Cranial Nerves of Cerebellum, etc.

the stomach, and *par vagum*, because so widely distributed to the heart, liver, etc. It has both motor and sensitive filaments, and ganglia. It has more extended distribution than any other of the cranial nerves, and in some respects is the most vital of them all.

Figure XXIV. shows the relative positions.

11. **Spinal Accessory.** So called because a part of it is accessory to the tenth pair. A part of it arises from the lateral track of the cord and gathers up fibers along the cervical portion of the spinal cord.

12. **Hypoglossal,** or chief motor nerve of the tongue.

8. All these nerves are more or less connected with the white and gray matter of the brain. They inosculate variously with each other by ganglia or plexuses, and often motor and sensory filaments and white and gray matter are brought into contact or communication.

There is thus a series of independent yet coöperative forces made harmonious by one presiding Maker; in parts so under the control of the will, and in other parts so independent of it, as to accomplish all that can be done by will-power, and all that is necessary to be done without it.

We have noted thus briefly the cranial nerves, because, as thus exhibited, we can come more easily to the idea that both as nerves of sensation and of motion, they have relation to our own personal and hygienic management.

Those least under our control, and meant to be independent of it, may, by disorder or abuse, so become involved as to change their rhythm of independent action into the most distressing contortions and spasms of movement. Others under our wills may be so wrongly educated as to be sources of pain rather than of pleasure. They will generally take care of themselves, if all the rest of the body is rightly kept. But if there is disorder of body, of will, of emotion, instead of being our instruments for self-control, they become our most perplexing enemies.

The system of nerve life is much like the delicate mainspring of a watch, which we do not need to fully understand. But we must learn not to abuse the instrument which contains such complicated work. We are finding out that just as there is an unperceived change which takes place in the minute molecules or structure of iron, by heavy and repeated strain, known as the fatigue-work of iron, so we may produce functional and organic changes of nerves which unfit them for the work for which they were intended.

9. The ultimate accomplishment of all education is to secure normal action of the entire nervous system; to secure for it the best conditions for health, and to prevent that impairment which gives rise to so many ailments. This glance at its minute complexity, and its relation to our inner selves and to the outer world, exhibits the fact that upon it chiefly depends all success in training the human being. This fact is all the more weighty and significant, because we are realizing that nervous impairment is becoming more frequent, that educational methods too often seem to increase it, and that great attention needs to be directed to such care of the body as will secure the normal action of all parts of this, its most delicate structure. Overstrain and overwork, if making their record here, have touched most vital parts. It will not do to load the mind with information, and in the act break down the material structure on which effectiveness depends.

While what we have thus far noted is the portion of the nervous system allied most closely to the mind, we need also to follow the completion of the cerebro-spinal system, as found within and along the spinal column, and the ganglionic system.

This figure shows the human brain (lower surface), the spinal column, and the cranial and spinal nerves.

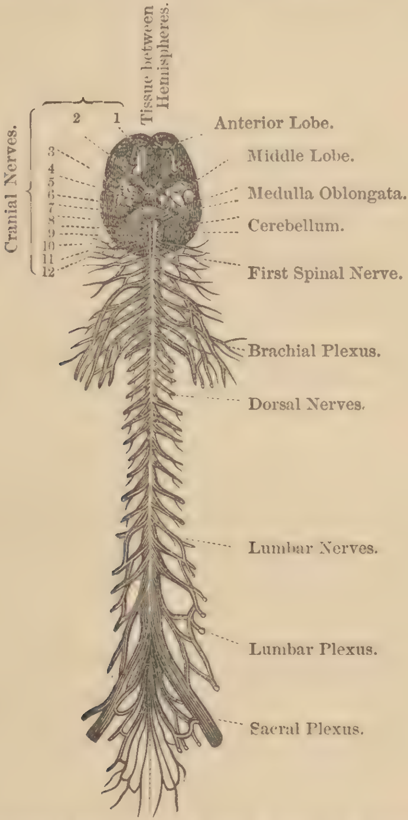


FIG. XXV.—Showing the Human Brain, and its processes.

10. Coming forth from the column, between the vertebræ of the backbone, are 31 pairs of nerves. Each one arises by two roots, an **anterior** or motor and a

posterior or sensitive root. The posterior roots have each a ganglion, except that it is, in some cases, wanting in the fifth pair. The motor are called the **efferent** (*ex, out of, fero, to bear*) and the sensory **afferent** (*ad, to, fero, to bear*) nerves.

"All the power of causing muscular contraction which a spinal nerve possesses is lodged in the fibers which compose its anterior roots; and all the power of giving rise to sensation in those of its posterior roots. Hence the anterior roots are commonly called **motor,** and the posterior **sensory.** A sensory nerve is a nerve which, when active, brings an impulse to the central organ, or is afferent, and a motor nerve, a nerve which carries away an impulse from the organ, or is efferent.

"When a limb, as we say, 'goes to sleep,' it is because the nerves supplying it have been subjected to sufficient pressure to destroy the nervous continuity of the fibers. We lose voluntary control over, and sensation in, the limb, and these powers are only gradually restored as that nervous continuity returns."

11. The grouping of the spinal nerves is as follows: —

Cervical	8 pairs.
Dorsal	12 "
Lumbar	5 "
Sacral	5 "
Coccygeal	1 "

These pass out through the intervertebral **foramina** on either side of the spinal column. The two roots, which are united just before passing out, after passing out divide into two branches of mingled fiber, an anterior branch supplying the front of the body and a posterior

and smaller branch supplying the back. These nerves **anastomose** in various parts and connections so as to form plexuses, and these variously intercommunicate with each other, with the cervical nerves, and with the sympathetic ganglia. Among the most prominent are the cervical, brachial, lumbar, and sacral groups, from which nerves are distributed in various directions, giving motion and sensation to the most distant parts.

12. The **sympathetic** system of nerves is the other remaining system now to be considered.

It consists of a series of ganglia, or knots of gray matter, connected by intervening cords, and extending along **each side** of the cerebro-spinal column from the head to the last bone of its column, communicating with all the nerves of the body, and giving branches to all the internal organs and viscera. As some of these organs are supplied by it exclusively, it came to be called the nervous system of organic life.

Each ganglion may be considered a distinct center giving off branches of communication, (*a*) between the ganglia (*b*) with the cerebral or spinal nerves or (*c*) to communicate with the other sympathetic filaments and the viscera and the ganglia located in the thorax, abdomen, and pelvis. These ganglia are about as large as a very small bean.

The chief ganglia of the sympathetic nerves may be classified as

Cranial or Cephalic	4
Dorsal	12
Sacral	5
Cervical	3
Lumbar	4
Coccygeal	1

From these we have nerves given off to various parts, and they are so distributed that we have besides a cardiac ganglion, cardiac plexuses, and pulmonary plexuses. The great **splanchnic** nerve, itself a sort of plexus, ends in the **semilunar ganglia** which form a part of a gangliform circle behind the stomach, known as the **solar** or **epigastric plexus.** From it we have ten or more plexuses to the stomach, liver, spleen, kidney, etc.

The two semilunar ganglia of the solar plexus are the largest ganglia in the body. It is because of this that a **blow** upon the **stomach** is so often serious, and sometimes quickly fatal.

The **lumbar** and **sacral** ganglia give off many nerves and filaments, but form only two or three plexuses.

The nerves which govern the walls or muscular fiber of the arteries, veins, and capillaries are called **vaso-motor nerves.** Impressions made upon them result in a change of the caliber of these vessels, and greatly affect our sensations.

Special regions of the spinal cord have the special function of acting as centers for these vaso-motor nerves.

13. As we view these two great divisions of the nervous system, namely, the **cerebro-spinal** and the **sympathetic,** we find them closely inosculating and connecting, and having many points of resemblance. Both are composed of white and gray matter. Although the white substance predominates in the brain and spinal cord and nerves, and the gray in the sympathetic system, yet the brain itself is made up of ganglia, and gray matter is found in it and in the spinal cord. In both, the white matter has to do with conveying impression and the gray with generating force, the one being as the battery and the other as the telegraphic wires.

Through the one, the system of animal life is controlled in parts by the will. In the other, the system of organic or vegetable life, the action is spontaneous, or without will power. Yet they are in close correspondence. Also in the cerebro-spinal system, in what is known as **reflex** action, we have a response of motor nerves to impressions and muscular action therefrom without any intervention of sensory or volitional power, as when the eyelids wink before a blow.

14. The stimulus or irritation applied voluntarily or involuntarily, directly or indirectly, to the ends of the afferent or sensory nerves gives rise to a molecular change, which is propagated along the nerves to the spinal cord, with which they are connected, and so is transmitted to the motor or efferent nerves, which pass from the spinal cord to the muscles affected. The brain also gives rise to some **reflex** actions, but the spinal cord is spoken of as the **central organ** of reflex action. The power is possessed only by the gray matter, and is not possessed by any ordinary nerve.

This reflex power, in which the sensory nerves carry a message to the central organ, which quicker than thought is reflected to the motor nerves, and so results in action, is a process constantly going on. Prof. Huxley well illustrates it, thus: —

"Let us consider what takes place in such an act as reading aloud. In this case, the whole attention of the mind is, or ought to be, bent upon the subject-matter of the book, while a multitude of most delicate muscular actions are going on, of which the reader is not in the slightest degree aware. Thus the book is held in the hand at the right distance from the eyes; the eyes are moved from side

to side, over the lines and up and down the pages. Further, the most delicately adjusted and rapid movements of the muscles of the lips, tongue, and throat, of the laryngeal and respiratory muscles, are involved in the production of speech. Perhaps the reader is standing up, and accompanying the reading with appropriate gestures. And yet every one of these muscular acts may be performed with utter unconsciousness, on his part, of anything but the sense of words in the book. In other words, they are **reflex acts.**"

The reflex actions proper to the spinal cord itself are **natural,** and are involved in the structure of the cord and the properties of its constituents. By the help of the brain we may **acquire** an infinity of artificial reflex actions, that is to say, an action may require all our attention and all our volition for its first, or second, or third performance, but by frequent repetition it becomes, in a manner, part of our organization, and is performed without volition, or even consciousness.

The **possibility of all education** is based upon the existence of this power which the nervous system possesses of organizing conscious actions into more or less unconscious, or reflex, operations. It may be laid down as a rule, that if any two mental states be called up together, or in succession, with due frequency and vividness, the subsequent production of one of them will suffice to call up the other, and that whether we desire it or not.

The **object** of intellectual education is to create such indissoluble associations of our ideas of things, in the order and relation in which they occur in nature; that of moral education is to unite as fixedly the ideas of evil deeds with those of pain and degradation, and of good actions with those of pleasure and nobleness.

Very much of intellectual acquirement is the conversion of volition into automatic or spontaneous power.

15. We are not able to detect a circulating fluid in nerves so distinctly as in blood-vessels. Yet from what we have found of the tubular structure of nerve fiber it is not mere poetry to speak of a circulating, vital, or nervous force. The state of the fluid may have very much to do with nervous action. Just as the waves within the ear-labyrinth are played upon by the waves of sound, so this nervous complexity is operated upon by a variety of forces. While brain and cord and ganglia everywhere have their own action as centers, they also have relations to each other. While each plays its own part, the whole complicated machinery moves on with a rhythm of continuous harmony so wonderful that we can but admire and adore.

16. **Nerve action** is the foundation element in health and disease. We need to avail ourselves of such forces as we find conducive to good nerve health, and to avoid those which interfere therewith.

When we do not fully understand a machine in all its mechanism and details, we may, nevertheless, become quite aware of the conditions under which it was made to run. So one may come to know very much about the functions of the nervous system and the conditions of its healthy exercise, and so treat it well, without an entire knowledge of its character or mechanism.

It is hard to get it out of order, numberless as are the present instances of its disorder. But once out of order, it will not be mended by any common tinkering. Nay, it is so much a high-wrought and divinely wrought

excellency, that human hands too often fail in attempts at such attainments of skill.

Beware that it be not jostled about too rudely, or handled carelessly lest the machinery becomes hopelessly ajar, or very difficult to repair. It has to do with **physical, mental,** and **moral** hygiene. Many a life is wasted or made erratic, because the error is made here. Not only the body weakens, but the mind loses its resiliency, and harmony of thought and action are impaired.

The great principle involved in a proper care of the nervous system is so to care for the body in all its parts as that it shall be properly nourished, and each function properly performed. Knowledge and experience must teach us the limits of nerve endurance.

When the eye becomes tired it is time to stop or change the glare of light, or in some other way seek restoration. So with every other organ, and with the mind itself.

17. The greatest difficulty with the nervous system is that it so often fails to have the aid of discipline and of will power. As there is tonic to the whole body in air, water, and sunshine, so there is tonic to the nervous system in willing obedience to that which is right in discipline, training, and self-control. We fortify the nervous system in studying how to control action, motion, sensation, volition, and all that appertains to that wonderful border-land between the voluntary and involuntary, of which brain and nerves are the communicating telephones.

Nervous diseases perhaps more than any other class of diseases are the outcome of wrong methods of conducting the daily discipline of voluntary life. A person

may become over emotional by over indulgence of the sensibilities; or ungovernable, because too frequently yielding to appetites or habits or passions; or unstrung, because the toil of thought has claimed too many hours and caused undue fatigue.

It is one of the results of the study of Hygiene, that it puts so many not only on guard, but into the **practice** of methods of consistent life. Thus there is adjustment of work to ability, of desire, to necessary control, until still greater powers are acquired, or the person learns the limitation of his power, and conforms his desires and his aspirations thereto. It also teaches us how much the nervous system is capable of education, how drill and discipline may correct abnormal tendencies. Thus a proper and healthy control of the nervous system may be maintained, and in many cases re-acquired, after symptoms of disorder have appeared.

18. **Alcohol, etc.** — The great risk incurred in the use of alcohol, opium, chloral, tobacco, and the long array of **narcotics** and **stimulants**, is that they make their quickest and profoundest impression on the nervous systems of animal and organic life. They touch the very mainsprings of life, and in a way that too often shows that we are tampering with that part of ourselves which we should touch the least frequently and the least rudely, unless we accurately know the ultimate as well as immediate effects of that touch. Ere we know it, we may disturb fibers and motions and sensations which it is hard to restore. We know not whether we are only affecting function, and that temporarily, or whether we are changing structure. Too often it is a process of education by which we impart real and

automatic desire in the wrong direction, and change of structure results. In the case of alcohol, we have abundant evidence that vital organs are engorged by the paralysis of the vaso-motor system.

19. **Overwork and overstrain** do their harm to the same intricate network, unless there is rest, recreation, and amusement. Most of all, **sleep** is the great panacea for tired nerves, and must never be shortened by those who would preserve the vigor of life, in its central axis, in the hidings of its power. If for any reason there has been loss of sleep, there must be compensation therefor.

Recreation and rest are additional aids. Food of easy digestion and in increased quantities will, to some degree, make amends for loss of sleep. But all who labor must **plan** for such amount of sleep as seems to be required. We know of a distinguished writer who keeps an account of his lost sleep-time, and makes it up by going to bed in the daytime each week enough to make up for any loss. It is far better to let work and rest alternate in close relationship.

Other invigorations of the nervous system are to be sought from exercise, change of air and scene, and sometimes by the use of special medicinal tonics. Let it ever be remembered that, in the ultimate analysis, the **welfare** of the nervous system is the radical aim and effort of all hygienic care. Out of it are the issues of life, for it is the mainspring of each organ, the presiding genius of each function, the basis and substance of all life.

20. The care of nervous condition, and the invigoration of the nervous system, are important parts of

the training and instruction of children. A headache is never to be trifled with, by urging the child on to intellectual work. It is a noble tact, a *tactus eruditus*, to be able to discern when the child labors too much in study, or is perplexed into worry by overwork. Trials with scores of children, oft repeated, have shown that no classes do as well in mental arithmetic in the afternoon as in the forenoon. Changes of study, and of the order of different grades of study, can be made to contribute to vigor. Irritability or discouragement in pupils is often mental tire.

Any distinctly nervous symptoms, such as twitching, sobbing, and excessive laughing, indicate the need of attention to the health, and the supply of such foods and tonics as are of recognized value. Spasm of any kind in children, even if no after effects appear, is to be taken as full notice that the nervous system is being impaired. Teachers need to study and discern the temperament of pupils and the nerve tonicity. There is no wear and tear like that of a disturbed nervous organization.

21. That plan of education which does not take into account the nervous organization is very defective. A correct plan of education must include what is sometimes called mental and moral hygiene. "It teaches the child to understand that he is the trustee of his body, by giving him general outlines of his duty to it and its wonderful power and readiness to serve him in return, so that he will instinctively respect it, and be really interested in taking good care of it, and acquire a natural presence of mind with which to meet its special and sudden requirements, without in any morbid manner

dwelling upon it and its functions. It instructs him in the general effects and uses of the emotions; that truth, unselfishness, courage, cheerfulness, patience, and kindness all tend to make him happy, and others around him happy, and that happiness is a great help, and indeed a necessity, to health. It shows him that undue emulation in study or play leads to overstrain of the body, and to the hateful vices of envy and selfishness,—vices which produce emotions directly and harmfully affecting health,—and that it is far better to be individually well, noble, and happy, than to be successfully competitive at so great a cost. It teaches that giving way to ill-temper produces special disturbances hurtful to body and mind; that bad habits, such as the use of alcohol, tobacco, opium, or other narcotic substances, have most mischievous effects on the nervous system; and are essentially silly, ignoble, and degrading; that the only true pride consists in being too proud to abuse the body intrusted to us, and too proud to be swayed by any opinions but those of the worthy and of the good." We must put our attention upon this broad study of Hygiene in all its relations, as we do upon the study of History or Geography, or any other branch. Only it is the trunk and timber of the tree of knowledge more than it is a branch. It is not only that care and exercise develop muscular power. The teaching is a discipline of will-power, an exercise of self-control, an aiding of the nervous system in that coördination and coöperation on which true life and true living so much depend. Industry, bravery, patience, prudence, system, equipoise, common sense, come out of such knowledge and such discipline.

22. True education is not only consistent with health, but is a culture of health. A trained mind not only has possession of itself for **thought,** but for the control of **physical** life. It looks after the condition of the machine which it is to operate and upon which its integrity and functions depend.

We must be convinced that the body stands in need of exercise and discipline as well as the mind, and then seek to learn the **process** by which it is to be trained and its good **ability** secured. In learning how to order the body aright, and how to have it fulfil our orders, we at the same time get mental and moral stamina. It is when seeking to develop the wholeness of our being that we get the benefits of education.

This, far more than what is spoken of as talent, gives success in life, and make it easy for the human animal to have power and influence both mental and moral. It is this well-fed, well-slept, well-trained, well-exercised nervous system, more than anything else that has to do with our whole well-being. This means all that can be meant for us in this world, and includes much that is hopeful for us as to the next.

CHAPTER XIX.

THE SENSES.

IN considering the nervous system, we have had occasion to notice **nerves** as the media or source of sensation and motion. Muscles contract in response to the motor or efferent nerves which are distributed to them. These nerves derive their activity from the central nervous organ with which the motor and sensory nerves are connected. The central organ is sometimes the brain, sometimes the spinal cord, and sometimes almost a prolongation of the brain, as with some of the special senses. The ganglia, and the various meshes and intertwining of nerves we have before noticed, also serve as points of departure.

Whatever this central point for motion or response be, it is thrown into activity by the sensory or afferent nerves to which the motor or efferent nerves respond. These, too, in various ways, connect with the central organ on the one hand, and with parts of the body on the other. The change which thus takes place first in the sensory or afferent nerve generally results from some **external impression.**

2. Most, if not all the voluntary movements of the body are affected by the process of stimulus proceeding from without, as has been indicated, and this, as quick as thought, is reflected back by what is called reflex

action. In addition to what we may call natural reflex action, we have seen that multitudes of reflex actions become acquired, so that things at first done through **teaching** come to be done automatically. Indeed, habit makes such actions as natural as **instinct,** or non-acquired actions, by the molecular changes which take place.

When, as frequently happens, movements or actions so affect our sensory nerves that we become conscious of them, we speak of them as **sensations.** These are a part of our consciousness, which, like primary beliefs and intuitions, have to be accepted as ultimate and indescribable facts.

3. We are aware of great variety in sensations, but it is not always easy to trace them to their center. Some, like fatigue, restlessness, despondency, irritability, we cannot assign to any particular place. Others, like faintness, or tendency to tears or emotions, we may or may not trace to some external impression. Some of them are natural, some of them the first slight advances toward disease. Volition strongly intermingles with them; education teaches which of them are to be **cultivated,** which **resisted,** and the method best adapted in either direction. All this class of sensations, while they may be affected by the external world, inform us nothing about it. They are purely **subjective** sensations; yet as we speak of educating the senses, we are also to recognize that sensations may be retained as normal and made more acute, or may be made abnormal and morbid.

We are able, quite distinctly, to separate them from what we are used to call **the senses,** and yet they admit of training.

4. There is one sense, known as the **muscular sense,** which it is difficult to classify. While having the same general origin and mode of operation as the sensations, it is in its power of receiving external impressions so analogous to some of the **organs** of sense as that many now classify it therewith.

This muscular sense is the sense by which we judge of the **relative weight** of a body, or the degree of resistance it offers to our effort to move it. It is different from touch or pressure or contact. It enables the person to form some idea of the weight of an article or its degree of resistance. The idea is not formed by looking at it or feeling of it, but by the muscular act of lifting. Some would include this as a result of external sensations, and classify it with the senses of touch, taste, smell, hearing, and sight.

5. Most of our sensations are **compounds** of different sensations with each other, or with ideas and emotions. Aristotle claimed that each of the five senses was only a modification of the sense of touch. Some have claimed the parental love of children as a special sense. The vocal power, or that of speech, some regard as a special sense. How two recognized senses act in combination is seen in the perception or sense we call taste, which, in its result, is largely made up of smell and touch.

Many of the conclusions we arrive at are dependent upon the exercise of mind or judgment, so that the **brain** is in a special sense as much an organ of sense or sensation as the eye or ear.

So complex is the source of our information as to the external world, that it is difficult to use such words as sensation, emotion, volition, and perception with pre-

cision. When I touch anything, my conclusions as to it are derived partly from sight, or experience, or judgment. By feeling of variously shaped blocks with the eye shut, we may render doubtful what would otherwise have been a clear perception of feeling. Sir Humphry Davy, in his early life, was assisting Dr. Beddoes, who cured diseases by inhalation of gas. Davy, in order to ascertain temperature, placed a thermometer under the man's tongue. The patient fancied that this was the wonderful inhaler, and had such a sensation of inhalation that the use of the thermometer, and nothing else, was continued for several days, and evident benefit resulted. "Our notions of singleness or roundness are really highly complex judgments, based upon a few simple sensations, and when the ordinary conditions of these judgments are reversed, the judgment is also reversed."

6. The cultivation and control of the senses is of great importance, both to render them accurate or automatic, and to prevent what is useless or harmful. How far single senses can be trained and made to replace others is illustrated in the blind and the deaf. There is, even without these extremes, a correlation which is wonderful. Sense, sensation, emotion, volition, thought, and judgment intertwine as wonderfully as does the wonderful machinery of the nervous system, and common sense is the presiding governor needed for the whole. Each teacher needs to appreciate the bearing of education upon **sensations** as well as upon the **senses.** We must know something of our great instrument, the nervous system, and play properly upon its chords, if we would rightly reach the mind of which it is the machinery.

With these preliminary suggestions, we proceed to notice the senses which have heretofore been classed as the **five senses.**

7. **The Sense of Touch.** — Our general sensibility is dependent upon the sensitive nerves of the cerebro-spinal system, which form the chief network amid the papillæ of the skin. Thus **the skin** becomes the chief medium of general sensibility; for sense of heat and cold, of roundness and solidity, and of moisture, fluidity, or felt motion, and various other forms of sensation, are acquired here. The **quality** of the sensation is much determined by the thickness of this covering, or by the fact that the deeper layer of the skin is raised up into elevations known as **papillæ.** Loops of capillary vessels enter these, and the sensory nerve-fibers distributed to the skin terminate in them. The sensibility of different parts seems to be principally decided by the number and prominence of these papillæ.

Valentin arranges the order of sensitive **perception** as follows:

Tip of the tongue; palmar surface of the tips of the fingers; of the second phalanges, and the red surface of the lips; of the first phalanges, and the end of the nose; the dorsum of the tongue; the dorsal surface of the phalanges; the cheeks, and back of the hand, etc. While two points can be distinguished by the tips of the fingers, if but one-twelfth of an inch apart, the two points of a carpenter's compass, three inches apart, may give but one sensation at the middle of the back.

8. Because the skin and the mucous membrane of the nose, mouth, and throat share in this sensibility,

differing in degree, but not in kind, we speak of touch as a **general** sense or sensibility, having no specialized organ. Buffon says of it, that it rectifies all the other senses. The modes in which it can be changed or developed are interesting. Even the impression which we sometimes have in the dark, that we are approaching a solid object, is a part of the sense of touch, as conveyed by the air.

So far as heat and cold are concerned, and in some other cases, the sense is relative rather than absolute. Huxley illustrates it by three basins, one having ice-cold water, one containing water as hot as it can be borne, and one a mixture of the two. If the hand is placed in the last, after it has been in the hot water basin, it will feel cold, but if placed in it after being in the ice-cold basin it will feel warm.

9. If the skin is brought too near the fire, it becomes more sensitive to cold. Much itching of the skin, chilblains, chapped hands, etc., are not so much owing to degrees of cold, as to sudden changes. None suffer so much from cold feet and hands as those who hold them much by the fire after being cold. There are very many ways of disordering skin sensations, which are owing to the undue alternations, to unevenness in the amount of clothing, difference of pressure and friction, etc. If these sensations are at once heeded, and the disturbed part bathed with a little borax or soda-water or glycerine, and the suspected cause avoided, the trouble ceases. If the sensations are neglected many of the varied forms of skin irritation are produced. Change of garments or covering, change of thickness, and change of habit as to exposure, are of great benefit in such cases.

10. What is known as the *tactus eruditus*, or learned touch, is, on the other hand, a proper and useful development of sensibility, and can be cultivated. Many of the arts depend on this. What we call handiwork is often the product of a cultivated **touch** as much as of a cultivated taste. We know an oculist who, in washing the hands and in the use of gloves, has in thought the preservation of his finger-touch, for the nice operations he performs. So the seamstress, the decorator, and all classes of expert artists, are greatly dependent upon this cultivated sense of touch. Persons who have been maimed have been taught to write with the toes as well as others do with the fingers.

In the blind we see this sense developed to such a marvellous degree as to indicate the possibility of high training. We are learning more and more how much all education is a **training** of the **senses**; their capacities, their record, and their ability, depending not less upon the uses to which they are put than upon their original endowments.

11. **Taste.** — The senses of **taste, smell, hearing,** and **sight** are those most frequently recognized as depending upon specially localized organs.

The sense of **taste** is located in the mucous membrane of the tongue, the soft palate, and the fauces. The mucous membrane of the tongue is raised into papillæ of various shapes and sizes supplied with sensory filaments from the trifacial and glosso-pharyngeal nerves. The same nerves give to the tongue general sensibility, so that it is an addition to the general sense of touch in this way. While it is, by the ordi-

nary sensibility of touch, in the mouth that we perceive hardness and softness, temperature, etc., the special sense of taste receives the impressions of flavor, acidity and alkalinity, and much of what goes to make relish or dislike, and the appetite. Even these are modified by the sense of smell, which can also reach it through the posterior openings of the nose. Thus in the mouth the three senses coöperate, and give to the gateway of the breathing and digestive systems their combined guard.

12. The sense of taste is an example of how, by **habit,** sensations which are unpleasant, or actually painful, may become agreeable. We find such to be the case as to very many sauces and condiments, which at first irritate and burn the mucous membrane of the mouth and throat so as to suspend taste, and even require treatment. Thus **cayenne pepper** and other severe irritants, are made pleasant to the taste, while at the same time they are doing their serious damage to the minute vessels and tubules of internal organs.

So **tobacco,** at first unpleasant, and causing a stinging sensation, is craved by the taste, until chewing, rubbing of snuff, and dipping have come to be practiced by those of both sexes, and of many climes.

Still more, the **alcoholic beverage,** which at first burns the mouth and throat so as to require much weakening, is, after a time, passed down the throat, fiery and stinging, with a relish. The perverted taste even makes the mouth to water for it, and the taste to crave it with an insatiable craving.

There are some appetites, which are but the demands of nature for food and for replenishment, but

too much of what we call appetite is perverted taste, asking more sensitively for harmful things than for the actual foods and sustenance of life. It is a familiar illustration, not only of how taste can be cultivated, changed, and perverted, but also illustrates how any sense may be either so educated, and improved or deranged and degraded, as to give to it the highest possibilities for good or for evil.

13. The sense of **smell** has for its organ that part of the nose lined by mucous membrane, upon which the filaments of the olfactory nerve are outspread, namely, the mucous membrane of the superior and middle **turbinated** or scroll-like bones.

At the upper portion is a delicate plate of the ethmoid bone, called the **cribriform** plate, from its sieve-like holes. Only this perforated, horizontal plate of bone separates the nasal cavity from the brain, so that the olfactory nerve, like the optic, is really more like a prolongation of brain than a distinct nerve.

The broad bulbs of the olfactory lobes rest upon the upper side of the cribriform plate, and from these the olfactory filaments spread out on the superior and middle turbinal or spongy bones, which are permeated by air-cavities connecting with the nasal fossa.

14. In the quiet flow of air to the lungs, the air of the upper chamber is not freely mingled with the former, and so when we wish to perceive faint odors we sniff the air so as to carry it into these interstices. The ill-effects of the use of snuff must be apparent to any one who will consider that this delicate sieve membrane is its receptacle. We sneeze through irritation of the fifth pair of nerves, which gives to the nose general

sensibility to the acrid or pungent substances which are felt rather than smelt.

It is evident how readily **odors** or air can be made to reach this olfactory chamber, and it is not improbable that the action of sedatives upon a headache, and even of anesthetics on the brain, is not merely due to inhalation into the lungs, but also to the vaporous emanations which may pass almost in contact with the brain, or be conveyed directly thereto.

As it is the upper portion of the nose that receives the impression of odors, we may smell not only through the nose, but through the open mouth. This is especially so in connection with the eating of food, and is serviceable in warning us of that which is disagreeable or in adding to the relish of that which is savory.

15. In a **cold** we lose in part the sense of smell, owing to the swelling of the membrane over the turbinated bones. Smell is much dependent upon the immediate **contact** of organic particles with moving air, chiefly in the upper nose, and so is impaired by anything that obstructs clear nasal breathing.

The sense of smell is the simplest of all, so far as it relates to dependence upon association with other senses. We get from it little idea of quantity, size, or weight, and it acts, not by contact, but upon vapor. The general sensibility of the mucous membrane is quite distinct from the special sense of odor. It is therefore, typically, a special sense.

It is a common observation, that mental associations are awakened by odors, more than by the impression of any other sense. **Dreams** are often caused by the foulness of the air. Odors will awaken some persons more readily than noises.

16. **Hearing.** — The sense of hearing has its special organ, the ear, and a special nerve known as the **auditory** nerve.

As the nerve of smell is spread out on the mucous surface along the turbinated bones of the nose, so the filaments of the auditory nerve are spread out in what is known as the internal ear. The **ear**, for convenience, is spoken of as consisting of three parts, — the external, the middle, and the internal ear.

The **external** ear consists of the expanded portion, external to the head, — and known as the auricle or pinna, — and the meatus or auditory canal leading to the middle ear. The extension at the side of the head has been termed the "handsome volute" to the human capital, and its lobes, the hanging ornaments to the head. It is mostly a firm cartilage, covered by skin, and so provided with muscles as to have firmness, and such slight motion as may be required. In fact, there are muscles for drawing the ear upward, backward, and forward, but the muscular fibers are not so abundant in man as in some of the lower animals.

17. In deaf persons, however, these muscles serve to change the shape of the ear, and make of it more of a tunnel for the collection of sound. The availability of an instrument, now in use for aiding hearing by pushing the ear forward, shows that the mere shape of the ear is no unimportant matter. Its size, shape, and convolutions have direct reference to its special purpose, namely, to make it effective in collecting the waves of air which produce sound. If put on upside down, or sidewise, it would not so well serve this purpose.

There is much difference in the shape of ears, as

much or more than in that of any other organ, and it is not infrequent that the two ears vary in some particulars. They are not so uniform as the eyes, but, as

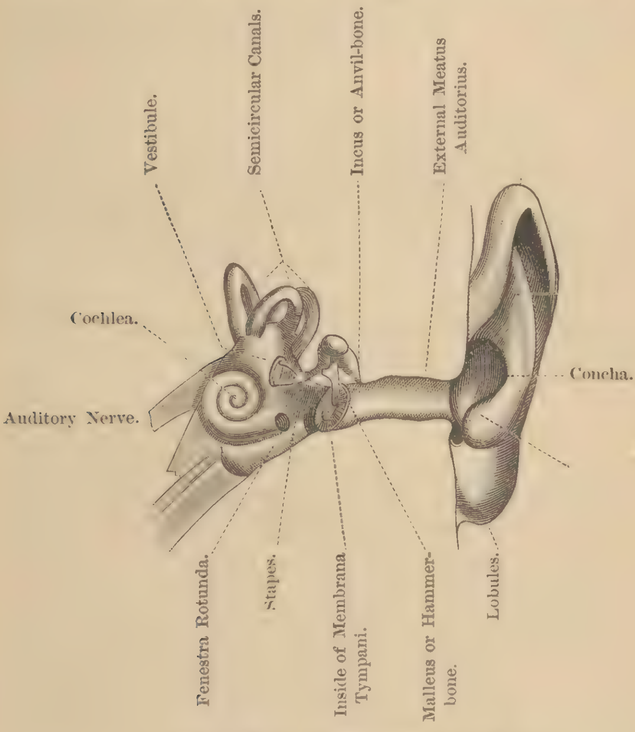


FIG. XXVI.—Diagram of the Ear.

we cannot look well at the whole surface of both ears at the same time, slight variations are not noticed.

The above figure gives the general structure of the ear.

18. The **auditory canal** is an oval cylinder reaching

from the concha, or root, of the external ear to the **membrana tympani,** or drum, which separates the external from the middle ear. It is about one and one-fourth inches in length, and so curved as to be higher in the middle than at either extremity, and a little narrower there. About one-half inch of the canal is cartilaginous, and the rest bony, or in the bony structure.

Two or three fissures in the anterior part make this portion, which is lined by a continuation of the external integument, slightly movable. The skin and membrane lining the ear is furnished with hairs and oil-glands, and further in are wax-glands which secrete the **cerumen** or wax. Both of these aid to keep out insects and foreign substances. The **ear needs washing** as well as the face, and the ends of the little fingers, when wet at the usual washing time, are well fitted to moisten the ear, while the towel or a soft rag will remove any accumulation. This gentle care of the ear is often neglected.

19. The **middle ear,** or **tympanum,** forms an irregular cavity in the petrous bone of the cranium.

The cavity is less than one-half inch in depth, and about one-fourth inch in its irregular diameter. It is closed in front by the membrana tympani, the delicate membrane stretched obliquely across the edge of the tympanum. This vibrates to the waves of sound, and transmits the vibrations to the small bones of the middle ear. The membrana tympani is impervious to fluids. The membrane is made tense or relaxed by the muscles of the middle ear.

The further end of the middle ear is bounded by the outer surface of the labyrinth or internal ear.

Air is admitted to the middle ear through a tube known as the **Eustachian** tube, which extends from the ear to the throat, and is about one and one-half inches long. The entrance of this opening from the mouth or pharynx to the middle ear keeps the air therein at the same pressure or tension as the external atmosphere. This often induces deaf people to open the mouth to hear, as thus some sound is gathered.

20. As we dissect the tympanitic membrane off from the entrance to the middle ear, we find that it is attached, on its inner side, to a small bone called the **malleus.** It is of hammer-like shape, the handle of which is fastened to the membrane, but so as to be movable. Its head fits into the cup of another little bone further in, called the **incus** or **anvil,** which has two prongs, one of which is attached to the margin of the opening of certain cells known as the **mastoid** cells, and the other ends in a little ball. This again articulates with a third bone, called the **stapes** or **stirrup.** These three bones are known as the **ossicles** of the ear.

This third bone is fastened to the **fenestra ovalis,** which is the little opening leading from the middle ear to that part of the labyrinth or internal ear known as the **vestibule.** The fastening is by means of a circular band composed of elastic tissue. Below, and slightly behind this, there is another little opening closed by a membrane, and known as the **fenestra rotunda,** leading to that part of the labyrinth or internal ear known as the **cochlea.** The neck of the stapes gives attachment to the **stapedius** muscle.

21. These bones are connected together, and with the middle ear, by three ligaments. They have at their

articulations cartilage and synovial membrane fitting them for motion. Two muscles tighten or relax the tympanitic membrane, and one probably so alters the angle of the stapes as to compress the contents of the vestibular portion of the internal ear. The tensor and stapedius muscles, acting together, **tighten** the tympanic membrane, and modify or restrict its vibrations. All this minute delicacy of structure indicates the need of protecting the ear from injury.

In addition to this chain of bones in this little rock cavern of the middle ear, there is on the posterior wall a larger opening, leading by several smaller ones to cells known as mastoid cells, which are in the mastoid process of the temporal bone, and vary in number and size. These multiply the vibratory surface, and so have to do with **resonance** of sound. The whole middle ear, as thus described, is lined with mucous membrane sufficiently moist.

It is apparent that the construction of this organ is such as fits it to be responsive to the play of some delicate ethereal power, and that no harpsichord of human mechanism was ever better fitted to respond to the human touch than is this to the tactile vibrations of the air. With all this wonderful machinery of the **middle ear**, the bones and canals are so minute, that the entire cavity would not contain over a half-teaspoonful of liquid.

22. The third part, or internal ear, already incidentally referred to, is called in general the **labyrinth.** It is a collection of cavities in the petrous bone known as the vestibule, the semicircular canals, and the cochlea. The semicircular canals may be included as a part of the vestibule.

The **vestibule** begins at the point where the middle and internal ears join, namely, at the **fenestra ovalis,** or end of the stapes, and has an irregular diameter of about one-fifth of an inch. At its farthest extremity is the **meatus auditorius internus,** which is the opening at which the auditory nerve issues from the brain to be spread out in its manifold filaments in the internal ear.

The **semicircular canals** are three in number, and above and behind the vestibule, but so much a part thereof as by many to be described as an appendage, or a part. They almost describe a circle, having a tubular diameter of about one-twentieth of an inch, and beginning and ending in the vestibule. This would make six openings, but as two of them run together, there are but five openings into the labyrinth.

At one end of each, where it joins the vestibule, there is a dilatation called the **ampulla.** Delicate but stiff nerve filaments abound in the inner walls of the ampulla, and these respond to any vibration occasioned in the watery fluid about them. Figure XXVII. gives a good idea of the wonderful construction of this musical instrument.

The **cochlea** (snail-shell) is a spirally-coiled canal, rather below the vestibule, in length and breadth only about one-fourth of an inch, consisting of two parts, the central axis or **modiolus,** and the spiral canal coiled two and one-half times around it, so as to make a length of about one and one-half inches. This spiral canal communicates with the middle ear by one of its openings. It has a thin membrane like the drum, and forms a mouth or funnel to the cochlea.

The interior of this spiral canal of the cochlea, lined by fibro-serous membrane, and known as the **scala media**, is divided into two passages by a septum, upon which nerve tubules are distributed.

23. The inner surface of all the osseous labyrinth of the internal ear, made up of the vestibule with its semicircular canal, and the cochlea with its spiral canal, is lined by a fibro-serous membrane containing a very little fluid. The fluid it secretes is known as the

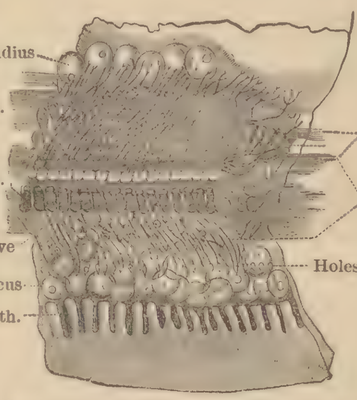


FIG. XXVII.—Terminal Auditory Apparatus.

liquor **cotunnii,** or **perilymph,** which thus fills also the scala media, or spiral canal of the cochlea.

In the vestibule and semicircular canals, it divides the osseous labyrinth from another sac, the membranous labyrinth yet to be considered, but in the cochlea, the fibro-serous membrane lines the two surfaces of the bony part of the lamina, dividing the spiral canal in which so many nerve filaments are distributed. It forms the membrane completing the division of the canal, and so is bathed with perilymph.

Inside of all this is another sac containing fluid, and this is known as the **endolymph.**

In the perilymph and endolymph are certain small, mobile, hard bodies, and the ultimate filaments of the auditory nerves are so distributed upon the walls of the sacs that their terminations must be knocked by the vibrations of these small, hard bodies, should anything set them in motion.

24. The vibrations of the fluid contents of the sacs themselves suffice to affect the filaments of the auditory nerve under the action of sound, just as the retina of the eye responds to light, but this is greatly intensified by these sand particles, just as the sand on the sea-shore gives vibrations to the waves.

Sound acting on the drum, or tympanic membrane, is, through the action of the three small bones before noticed, made to impinge on the **fenestra ovalis,** which leads to the internal ear, and so causes vibration throughout the fluid of the perilymph. This, in turn, reaches the **fenestra rotunda** and the endolymph, with its **otolithes** or gritty particles, and so the filaments of the auditory nerve are reached.

The auditory nerve at the **meatus auditorious internus** divides into two branches, known from their distribution as the vestibular and cochlear, and these again divide into branches and filaments until the nerve itself is outspread into a nervous membrane.

It lines the surface of the **modiolus** or **calumella** of the cochlea, and spreads itself like minute harp-strings over the spiral canal. These filaments are known as the fibers of Corti. With the microscope we can count 3,000 or more. Fig. XXVII. shows this internal ear apparatus.

Professor C. F. Brackett simplifies the description in this way. The tympanum is a drum-head placed obliquely. The three bones, as so many levers, serve to change its tension. These in turn connect with a bladder-like sac filled with water, inside of which is another movable bladder-sac, also filled with fluid. In contact with it, nerve filaments are spread out. It has little sand-particles in it.

25. Now, when the tympanum is impinged by waves of sound, the effect is felt first on the bones, and conveyed to the first sac of water, and then to the second, setting its waves in motion, and these, with the grits impinge on each nerve fiber, and so the effect, soft or hard, high or low sound, is struck against these nerves and conveyed to the seat of consciousness.

Professor Donders states the time occupied in the transmission of a sensation from the ear to the brain, the formation of a judgment, and the transmission of volition from the brain to the hand, at .09 of a second, while in the case of sight it is .15 or .17 of a second. At one point, the nerve fibers are arranged harp-like, so as to give 400 sensitive cords to each octave, of which the interval of space is one-sixty-sixth of a note.

Even this description gives but little idea of the intricacy and marvellous art of arrangement. The wonders of the ear are only less thought of than those of the eye, because the organ is so little seen, and was not so early investigated. Sound, in its record and action and response, is as remarkable as light. Its relation to knowledge, to voice, to music, and to life is so delicate and intricate, that lost hearing is often harder to restore than lost sight.

26. Of the hygiene of the **internal ear** we know nothing. That of the middle only concerns what we can do for the Eustachian tube which connects it with the throat, and for the tympanic membrane, or drum, which separates it from the external canal of the ear. Now and then, sudden or prolonged deafness occurs from enlarged tonsils, or unhealthy condition of the pharynx part of the throat, or from swelling of the tubes, or the impaction of mucous in them.

It has been necessary to refer to the anatomy, and its mode of function, because of its intimate relation to the **middle ear.** This has relations with the throat and the external ear in such a way as makes the care of it most important. Nearly all the cases of severe or permanent deafness involve the middle ear. As its function, and often its organic condition, depends much on the access of air through the eustachian canal leading from the **throat,** it must be kept in a healthy condition. Unfortunately, sore-throat, enlarged tonsils, severe cold, and various conditions of the fauces or region of the palate, too often give rise to disease of the middle ear. The condition of the throat should therefore early attract attention. Noises in the head, or dullness, or over sensitiveness to sound, should lead to inquiry as to its condition. Frequent rinsing of the **throat is of great service.**

27. The membrane of the ear is sometimes affected or destroyed by disease of the middle ear. Scarlet-fever sometimes causes disease here. One or more of the minute bones of the ear sometimes penetrate the drum, and are removed, causing loss of hearing.

The membrana tympani, or drum, may suffer inflam-

mation. It is occasionally fractured by the discharge of cannon or other sudden noises. Ear-ache is never to be trifled with, as only the skilled physician can know whether it indicates disease of the internal or external ear.

Injuries to the **external ear** may occur from injury to the drum, or from cold or inflammation. Sometimes the wax or natural secretion of the ear becomes hard so as to cause irritation or deafness. This is especially liable to occur when the ear is much exposed to dust, or is not well cared for by washing. Sometimes children put beans or pebbles into the ear, which, from the narrowness and uneven caliber of its canal, are difficult of extraction. Their removal is made more difficult because of the unsuccessful efforts of unskilled persons.

28. If the ears are systematically cleansed in the manner already indicated at the usual washing-time, and if they are not irritated, or unduly exposed to cold, they are not likely to need other attention. Soft linen or tissue-paper answers well for drying them. When the wax is tenacious or the orifice dry, the use of warm borax-water, so that some of it gets into the ear, is effectual. Where there is tenderness of the ear, or where there is exposure to intense cold, a minute piece of soft wool in the ear is a good protection. Ear-ache is often caused by the retarded secretions. The habit of keeping wool or cotton in the ear is not a good one. Pains about the ear are often neuralgic in their character. All sharp pains of the ear should be controlled by an opiate until the doctor is summoned.

In cultivating the ear for music it is not so susceptible of weariness as is the eye, but nevertheless there may

be too continuous application. Like all the senses, hearing needs alternations of rest.

We are all familiar with the degree to which delicacy, correctness of aural sensation and perception admit of cultivation. There is nothing in any organ of sense so wonderful as the mode in which we are made conscious of degrees in pitch, quality, and the various variations in sound.

CHAPTER XX.

THE SENSE OF VISION.

THE sense of sight is exercised through the eye as its organ, and the pair of nerves known as the optic nerves. In its wonderful mechanism, the eye impresses itself at once upon our attention more directly than any other organ of sense. It seems like a window to the intellect, through which the outer world looks in, and by which much of the material for thought and knowledge is conveyed to the mind. It also seems as an organ through which the mind looks out, and so gives us impressions as to the faculties and emotions.

2. It may be defined as an optical instrument, so fitted to light as to receive the images of objects, and to give to the mind a right impression thereof. It is so provided with machinery for protection and adjustment as to suit it for all reasonable variations of distance, or of surrounding media.

As it is more illustrative and simpler to consider the eye from without inward, we will begin with the appendages which have to do with its protection, and its more perfect usefulness.

3. The **eyebrows** form an arch over the cavity for the eye, and are so set with short, thick hairs as to impede sweat, dust, or other material from settling in and about the eye. They serve also for the attachment

of muscles which aid in controlling the amount of light admitted to the eye. Under a sudden blaze of light, we quickly, and almost involuntarily, draw down the eyebrows and diminish the aperture.

The **eyelids** are two thin folds of integument, the upper being more movable and larger. Both are furnished with two or three rows of hairs, which by their setting, and their celerity of movement, afford protection to the eye. The **tarsal** cartilages on their edges gives them form and support. On their inner surface they are set with glands known as the **Meibomian** glands. There are about twenty or thirty on each lid. These resemble the oil-glands of the skin, and keep the mucous membrane of the lids and of the eye surface bathed with a watery and slightly mucilaginous secretion, which prevents dryness and adhesion of the lids. The form of inflammation commonly known as **sty** is a stoppage of some one or more of these glands. The mucous membrane which covers the eyelids on the inside, and is reflected over a part of the eye, is called the **conjunctiva.**

At the inner **canthus** or corner of the eye is a small red spot known as the **caruncula lachrymalis.** It is made up of follicles like a gland, and produces a whitish secretion a little different from that of the Meibomian glands, such as is often found at the inner corner.

4. The **lachrymal** or tear apparatus consists of a gland situated in a depression at the upper outer angle of the orbit, about the size of a small plum-stone, having ducts six or eight in number, which open by rows of capillary tubes on the upper and outer part of the conjunctiva or mucous membrane of the upper eyelid, and are so arranged as to moisten the whole

eye, winking being a special means of distributing the moisture. Under strong emotion the flow becomes greater, and our feelings are expressed by tears.

But under usual circumstances there must needs be an arrangement for carrying off this secretion without having it always flowing out over the eyelids. To this end we have at the inner canthus, or corner of the eye, small orifices in each eyelid constantly open, which can be seen, and are known as **puncta lachrymalis.** These lead into capillary canals called **canaliculi,** and these again into a little reservoir known as the lachrymal sac. From this goes a duct known as the **nasal duct,** which carries the superfluous tears into the nose. Its value is appreciated by those who, having had this duct obstructed, are compelled constantly to use the handkerchief. A chaplain of the House of Representatives was gratified at the impression he was making on a Congressman, until informed that his use of his handkerchief was owing to this infirmity.

The eye being provided with these appendages to secure its cleansing and protection, is so situated in a bony orbit as that it is well protected on all other sides from injury. The cavity is formed by the joining of several bones, and thus an arch or socket is made about this precious organ.

5. The ball of the eye, or eye proper, may be described as a body spherical in form, of diameter a little under one inch, made up of several successive layers or coverings, between which are refracting media or humors. The optic, or special nerve of sight, enters this orbit from the posterior part, the whole being supplied with nerves and blood-vessels, and operated by several muscles.

This figure will aid in the explanation of it.

These layers or coverings are three in number. They are as follows: (*a*) the sclerotic coat and cornea, (*b*) the choroid, iris, and ciliary processes, (*c*) the retina.

The refracting media are three: (*a*) the aqueous humor, (*b*) the crystalline lens and capsule, and (*c*) the vitreous humor.

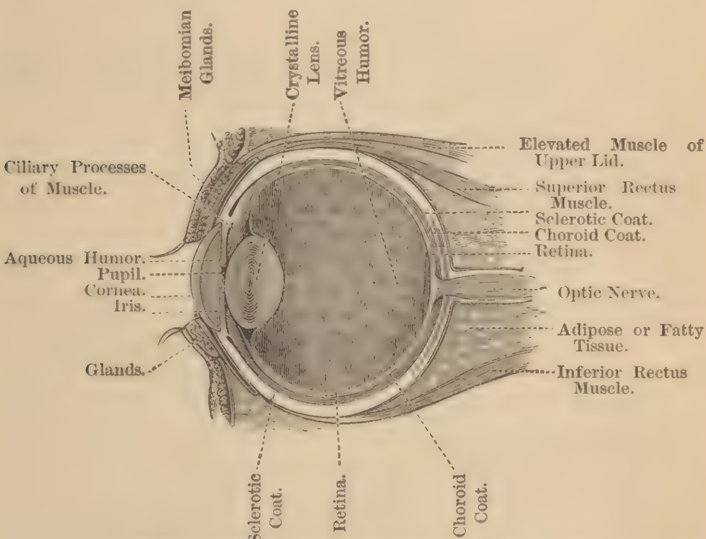


FIG. XXVIII.—Vertical Section of the Eye.

As you look at another's eye, you see first a whitish coat, in the center of which is a smaller disc, through which is an opening changing in size with the degree of light. The first is the **sclerotic** or hard coat of the eye, the second being the **cornea,** set in it like a watch-glass, and having the opening referred to. The

cornea forms about one-sixth of the surface of the eye, and is a little longer in its transverse than in its vertical diameter. The muscles which move the eye are inserted into the sclerotic coat, and through it are distributed various nerves and blood-vessels needed for the sensibility and vitality of the eye structure.

Removing this layer or covering of the eye, as you would the peel of an onion, a little transparent fluid exudes. This is what is known as the **aqueous humor.** It forms several drops, or four or five grains in weight, and has alkaline reaction. This aqueous humor fills the anterior chambers of the eye. It is adjacent to the sclerotic and cornea on their entire inner surface, and also to the next tunic, or coat of the eye. The space bounded in front by the cornea, and behind by the front of the iris and the ciliary ligament, is called the **anterior chamber** of the eye.

6. The second coat of the eye, as we pass inward, is as if, taking off the outside covering of a ball, you found a second one made up, for instance, of muslin, silk, and linen pieces, instead of one covering such as the leather-like sclerotic and cornea.

The strip, or circle in front, right behind the cornea, is called the **iris,** with its ciliary processes, — that by the edge, where the sclerotic, and its watch-glass the cornea, join, is called the **ciliary** ligament and muscle, and the part of the tunic, or covering making up the other five-sixths of the globe, is called the **choroid** coat.

The **iris,** so called from its rainbow or varied colors, is that little colored center you see when you look into a person's eye to tell whether he has black, gray, blue, or hazel eyes. The small black opening in it,

which contracts or expands as the light is less or greater, is called the **pupil.**

The iris is like a fold directly behind the cornea. It has its delicate fibers of tissue radiating toward the pupil, its muscular fibers for contracting the pupil, and its pigment cells.

7. The **ciliary processes** consist of appendages or folds, formed by the plaiting of the middle and internal layer of the choroid coat, and arranged in a circle behind the iris, and around the edge of the lens. They are from sixty to eighty in number, their periphery being attached to the ciliary ligament. The central border is free. On its margin, which nearly corresponds with the juncture of the sclerotic and cornea, you can perceive a narrow white ring. This is the **ciliary ligament** and ciliary muscle, which form the edge of the iris, and so the continuation of the second coat of the eye as it merges into the remaining portion of the second coat, known as the **choroid.**

The ciliary ligament connects the external and middle coat of the eye at this point. The ciliary muscle, Bowman supposes, is so placed as to draw the crystalline lens forward, and so adjust the eye for near vision.

8. The **choroid** coat, which in extent very nearly corresponds with the sclerotic part of the first coat, or tunic of the eye, is a vascular membrane of dark color, made up of three layers, in which blood-vessels abound. The inner layer is made up of cells, with pigment matter arranged in tesselated form. The cells are so delicate that a stream of water will wash the black substance off. Immediately behind the pupil, or opening into this iris, is the **crystalline lens,** through which all

light must pass and be refracted. This lens, of which an eye-glass or spectacle may serve as an illustration, is a transparent body enclosed in a very elastic and transparent membrane known as the **capsule** of the lens.

The lens is about one-third of an inch in its transverse diameter, and about one-fourth of an inch in depth. It is convex, both on its outside and its inside surface, but more on its inside, or rear surface. If we take off the capsule we find the lens made up of one peel after another, each layer of membrane being harder or denser than the next outer one, until we come to the hard, central nucleus.

This capsule and lens has a suspensary ligament which aids to keep it in place.

9. The **retina** forms the third coat, or tunic, of the eye. On its outer surface, it is in contact with the inside layer of the choroid, or second coat; on its inner surface with the vitreous, or third humor of the eye.

This retina is a delicate nerve membrane, and by some has been styled the outspreading of the optic nerve with which it is continuous, just as the nerve of smell is spread out in the nose and the nerve of hearing in the ear.

It is spoken of as made up of three membranes, the external, the middle or granular, and the internal or nervous. All the blood-vessels ramify freely through the internal layer. Upon this delicate membrane, after passing through the previous coats and humors of the eye, the images of external objects are received. The thin layer which connects the anterior margin of the retina with the surface of the crystalline lens is known as the **zonula ciliaris.**

10. The cavity within this retina, or third tunic, into which light is admitted through the cornea, the aqueous humor, the iris, and the crystalline lens, is filled with what is known as the **vitreous humor.** The vitreous humor is an albuminous and very transparent jelly-like fluid, enclosed in a delicate membrane, and forms the chief part of the bulk of the inner eye. This humor thus enclosed is hollowed in front to the shape of the crystalline lens. It is also connected with its suspensory ligament.

The optic nerve enters the globe of the eye at the posterior part, a little to the nasal side of the center, through the optic **foramen,** directly from the brain, and pierces the sclerotic and choroid coats, and expands into the nervous membrane of the retina.

We noted, in the chapter on the nerves, how the two optic nerves cross before emerging from the brain.

11. The ball or globe of the eye is moved by six muscles, two known as oblique and the other four as straight.

These are inserted into the sclerotic coat of the eye, and, acting singly or together, roll the eye in many directions, and give it power of retraction in its orbit as well as of slight protrusion forward.

The superior oblique muscle is especially worthy of note as having its line of direction changed by passing through a pulley at the internal angular process of the frontal bone, so that it can roll the eye inward and forward, and carry the pupil outward and downward.

"Such is the perfection of the mechanism, that the cornea is raised or lowered without the least lateral deviation, like the objective of a meridian-glass; and

the eye perceives by this succession of movements if the image of a line on the retina deviates two ten-thousandths of an inch from the vertical."

12. We have thus considered all the apparatus concerned in carrying the sensation of light to the brain, and now we must needs see how the mechanism accomplishes its object. This is necessary because so many

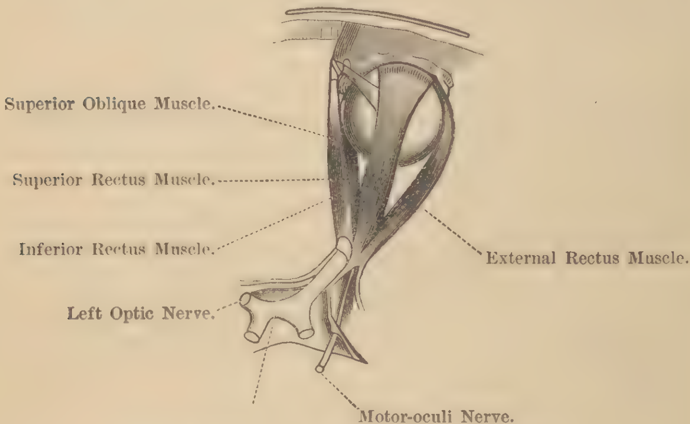


FIG. XXIX.—The Muscles of the Eyeball.

errors of vision result from not understanding these relations. Light, which consists of undulations in an ethereal medium, is so modified in passing through the transparent portions of the eye as to form images of the objects from which it proceeds. From these images the brain derives correct impressions of the objects themselves.

If we go into a dark room and light a candle, how shall we throw an image of the candle on the wall?

We can do it by taking a lens, say a piece of glass, convex on both sides, and, holding it between the candle and the wall, farther or nearer, until we find that it will cast the image. The point at which this image is best cast is called the focus. It will be brightened or dimmed, diminished or enlarged, as we change the candle nearer or farther from the lens. We will thus be able to determine at what distance we secure the greatest size consistent with distinctness. This is the right focus for that lens. Here we have the principle of the human eye.

13. An image of the object to be looked at is to be made on the retina, which is the wall or surface on which it has been arranged that the image must be cast, in order that the brain may take cognizance of it, and receive such impressions as shall give an accurate conception of the object observed.

Light is received through the watch-glass of the sclerotic or outer coat, namely, the cornea. Refraction, or the proper bending of the rays of light, depends somewhat on the convexity of the cornea. It also finds in the aqueous humor a medium of some refractive power, this humor being also of service in distending and giving shape to the anterior chamber of the eye.

Light thus comes to the iris, which is a self-regulating diaphragm or curtain, with a hole in it, which expands or contracts to the stimulus of light, and so regulates the quantity, letting in or shutting out so much as is needed to secure a proper image of the object looked at. Longet calls it an "intelligent diaphragm." By cutting off side or marginal rays, it overcomes certain well-recognized optical defects which would otherwise result.

The use of a diaphragm, or dark plate with a hole in the center, in the ordinary camera obscura, is for the same purpose. In perfecting many optical instruments, we learn to avail ourselves of mechanism similar to that of the eye. But the iris has this great advantage, that it is self-regulating.

14. Over all the inside of the choroid coat, which with the iris forms the second coat of the eye, and to which light thus gets access, there is a **black pigment** as well as over the posterior surface of the iris and ciliary processes. This, like the blackening of parts in the interior of the telescope and magic-lantern, serves to absorb scattering rays of light, and prevent such reflection as would obscure vision. Where, as in albinos, there is an absence of pigment, there is imperfection of vision.

Thus guarded against any sources of optical confusion, the light, passing through the pupil of the iris, comes to the crystalline lens, the design of which, like the lens used with the candle in the dark room, is to cast an image of the object seen, at the proper focus. This focus, in the case of the eye, is the **retina**, or third coat of the eye, the membrane which — the vitreous humor intervening — is to receive the image ready for the perception of the brain, or mind. This vitreous humor, with which light comes in contact, as it passes from the crystalline lens to the retina, not only gives shape to the globe of the eye by extending it, but has some office in connection with the refraction or proper adaptation of light. Refraction, we have already noticed, is chiefly accomplished by the cornea and aqueous humor.

If every part of the eye has, up to this point, done its duty, or been complete in its office and adjustments, the retina receives the perfect impression, and the object is correctly seen.

15. But as the eye has to deal with different degrees of light, it has constant occasion for adjustment in order that the retina may always be at the proper focus. If the image is thrown either in front of it, or so that the rays fall too far back, sight is imperfect.

This adjustment occurs in various ways, by the action of the muscles, by the contraction or expansion of the pupil, by the refracting power of the different humors, by the absorption of the scattered rays, by the pigment, but chiefly by the fact that the crystalline lens can alter its convexity, and perhaps its position, in its adjustment of the vision to different distances.

In instruments we have to change the lens, but the eye is self-adjusting. Tyndall, after some criticisms on what he calls its imperfections, says that, "as a practical instrument, and taking into account the adjustment by which its defects are neutralized, it must ever remain a marvel to the reflecting mind." If a person has a cornea more convex than usual, or if some other cause increases the refractive power of the eye, objects at a usual distance for good eyes are seen indistinctly, because the shadow is cast in front of the retina, or proper focus. Short-sightedness is the result, and there is need to wear concave glasses, which, by making rays diverge, counteract the excessive refractive power.

Not only the shape of the cornea, but greater or less convexity of lens, has to do with near-sightedness.

If the cornea is too flat, as often happens in old age,

or if from any other cause refractive power is too small, the person is too long or far sighted, and the book for reading has to be held too far off. In this case convex glasses must be worn to make the rays converge, for the shadow is cast too far back.

16. It is well to bear in mind, that "even in those phenomena which at first seem purely physical, we must not forget that the refracting media of the eye are organized, and cannot be compared, except by approximation, to inorganic bodies, on the form or density of which physicists base their calculations. This is necessarily the cause of the difference in the theories promulgated in regard to vision; for although the eye in some respects may be considered as an optical instrument, we can never arrive at exact deductions by comparing organs analogous, or even similar in their construction, but different in their nature."

Behind the retina, no mortal has as yet described the mechanism, and yet the sensation of light occurs, and the brain takes such cognizance of the delicate undulations of the rippling light waves impressed on the retina, as, like a telegraphic record, to declare the meanings of form, shape, and color, and transform them into conceptions, perceptions, and living thoughts, reaching out to a great infinity of knowledge.

The study of the eye involves, not merely a knowledge of optics, as presented in the text-books of physics, but also an appreciation of its complete adaptation to its design. As we study the contacts of mind and matter, it is all the clearer that these and their instruments were made by a Maker "knowing how," to an extent on which no shadow of doubt is thrown, except

by certain philosophers, who, in the use of the senses provided, fail to realize their own finiteness in the midst of such infinite perfection.

When we consider how much the eye is used and misused, and yet how seldom, comparatively, it fails in its work, we cannot but devoutly admire the wonderful power of this window for the brain which lets in so much of the light of the world, and is so much the expression of that intellect within, which has appropriated knowledge, and made it the medium for benefiting the world.

17. We now notice some of the more common affections of the eye, which require **hygienic forethought** and **care.**

The affections of the **eye** which are most frequent are those having to do with its appendages or chief outside protectors. These are the **eyebrows, eyelids,** the **conjunctiva,** or inner lining of the lids, and the **lachrymal glands,** with their secretions and ducts. Strange as it may seem, among the disfigurements of the face which have been called adornments, there has been either the removal of the hairs or the painting of the eyebrows so as to interfere with their natural purpose. A slight irritation of the minute glands in the eyelids is often the first signal that the eye is being overtaxed. This also is the first signal that they are being subjected to bad air or improper light, or that there is congestion about them.

The form of pimple known as a **sty** has its origin in these glands. The secretion from them helps to lubricate the eyelids, for the thousands of movements they make each day. If this secretion becomes **viscid** it acts as a direct irritant to the eyes.

18. There is also a contagious form of inflammation of the lid-margins and of the roots of the eyelashes which does an immense amount of mischief, although it is not so often destructive to sight as is purulent ophthalmia.

The careful washing of the eye each day with cool or cold water, and the avoidance of bright light, especially in reading or study, is very important when the eye shows any affection of the lids.

When the lids are disposed to stick together, they should be bathed at night along the edges with a little glycerine, or glycerine mixed with a solution of borax. If the **eyelashes** are at all fastened together in the morning, a mild solution of soda or borax should be used. Too often the foundation is laid for a very troublesome irritation of the eyes by carelessness as to the lids.

19. Besides this secretion there is another, more abundant, from a small gland for each eye, lodged in the orbit, on the outer side of the ball. This **lachrymal gland** has several small ducts opening on the inner portion of the eyelids. Its purpose is to furnish to the eye a constant cleansing water, which shall moisten and wash its surface, and then pass off through the duct before noticed into the cavity of the nose. If the eye be irritated by dust or pungent vapors, or if the emotions be greatly moved, the secretion from these lachrymal glands comes faster than it can be carried off into the nasal ducts, and there is an overflow of tears. This also happens when the duct has become occluded. Of this the first symptom is a slight swelling in the inner corner or **canthus** of the eye. It should receive immediate attention. If neglected, a small abscess may

form, and the duct become permanently destroyed, so as to cause a constant slight overflow of tears at this point.

20. At the edge of the eyelids, the skin changes to a delicate vascular mucous membrane known as the **conjunctiva,** which lines the lids, and is reflected over the front of the eyeball. This membrane is highly susceptible. Foul air, irritating substances, specks in the eye, or improper use of the eye, often cause its highly vascular structure to become congested. This is the usual form of sore eyes. It often passes on to a chronic form, in which the minute vessels, and the tissue surrounding them, become raised above the general surface of the conjunctiva, and so, in the form of **granular lids,** act as a foreign substance.

There is no organ to which **preventive treatment** is more important than for the eye. At the beginning of excessive watering of the eye, a little rest, or the use of a slight alkali, as soda, or a slight astringent, as cold or lukewarm tea, is often of service. When there is any increase of trouble, skilled advice must early be sought.

Those who have the care of children should be quick and careful to notice any disease or soreness of the eye. Not only the use of the same towel, but nearness to the secretions from sore eyes, often communicates disease therefrom to the eyes of others. When **specks** of any kind get into the eye, if they are not sharp so as to have penetrated its coats, a holding of the eye still and shut until it is filled with tears will often wash out the offending substance. Rubbing of the eye is to be avoided. A turning of the upper lid, or a pulling

down of the lower so as to see the speck and remove it with the twisted point of a handkerchief, may be well done by any person of usual dexterity. But it must always be remembered that the coverings of the eye are delicate, and that nothing irritating must be used.

21. Sometimes a little capillary vessel in the eye is injured so as to cause a **blight** in the eye. This is generally not so serious as it looks, and it passes away in a few days. This outside care of the eye is important, because, although there is seldom loss of sight from **conjunctivitis,** or inflammation of the coverings of the eye, the usefulness of the organ is often greatly impaired by it.

The eye is sometimes drawn away from its natural position by an affection known as **squint,** or a cast in the eye. In squinting, the axes of the eyes do not converge equally toward the object viewed. There is an irregular action of the muscles of the eye, or a confirmed failure on the part of one or the other of them to do its whole work. While sometimes resulting from disease, squinting may occur from habit. Where any tendency thereto is perceived, the eyes can be exercised by using one at a time, and looking with it in a direction opposite to that toward which it inclines, or using the affected eye a little from time to time, with the finger extended over the nose as an additional septum.

22. The affection which is most common in early life, and which is too often promoted by study and habits of school life, is **myopia,** otherwise called short-sight or near-sightedness. It is an over convergence of the rays of light, so that, being too much bent or refracted, the

rays unite before reaching the retina, and so come to it overcrossed. It may here be said of all diseases or disabilities of the eye not superficial, and so not recognized to their full extent by the casual observer, that they often account for failures in study, and what is regarded as dullness of perception in pupils. It is the experience of oculists, that school-boys and school-girls who come to them with eye troubles, on being questioned, confess to having been much scolded for imperfect lessons or stupidity.

Myopia, or short sight, is much more an acquired than an hereditary disability. Among the causes recognized are:

(*a*) Bad light; (*b*) bad form or size of type, poor printing, or paper bad as to quality or color; (*c*) improper positions in study; (*d*) bad ventilation or heating; (*e*) overwork, or whatever tends to congestion about the head; (*f*) neglect of exercise for the body as a whole.

The limits of a normal or healthy vision have been quite accurately determined. The **test-types** of Dr. Snellan are those generally adopted by oculists. A few of them are here given. The figures over the letters indicate the distance at which they will be distinct to the normal eye.

Variations from normal vision may be recorded by using the numerals given as denominators and the distance in feet at which the letters are clearly seen as numerators; thus, if letters which should be legible at 10 feet can only be clearly perceived at 5 feet, vision = $\frac{5}{10}$.

1 ft. 8½ in.

SLAHOTEUDG

2 ft. 6 in.

TSODHCULFE

3 ft. 3½ in.

FOECHSUTDL

4 ft. 6 in.

ECLSUTFDOH

6 ft. 1⅓ in.

SLFDCEUHTO

7 ft.

DFSELUHCTO

9 ft.

THDFSDUOLHEC

10 ft. 1½ inches.

ECHDLUTOFS

The following words represent well-known sizes of types:

Pearl.	*Agate.*	*Minion.*	*Brevier.*	*Long Primer.*
Whilst	dying	embers	through the	room

Small Pica.	*Pica.*	*Great Primer.*	*Double Pica.*
teach	light to	counterfeit	a gloom

Pica type should be used in teaching children to read, and is the best for ordinary reading.

We quote as follows from **Dr. Andrews**: —

23. "The reason why **myopia** is not unfrequently produced in school life can be easily conceived when we remember to how many of the influences above referred to, the eye of the child may be subjected.

"The **near-sighted eye** is one which has too great a diameter from front to rear. The result is that the rays of light from objects which should be brought to a focus upon the **retina** at the back part of the eye come to a focus from objects at a point nearer the front of the eye. If the light is thus focalized before reaching the retina, there is a diffused or indistinct image for which the person seeks, to make up by a nearer approach of the eye. This adds an additional evil by a greater exclusion of light.

"In early life the tissues are soft. Some eyes are believed to have a more yielding or plastic tissue than others. The extensible, sclerotic coat becomes stretched. The yielding occurs most at the rear of the eyeball, which thus becomes elongated. So the retina is moved behind the best locality for focalizing. No doubt this exists sometimes as an inheritance or an anatomical defect. But far oftener it is a yielding caused by the improper use of the eye.

"The act of accommodation of the eye is, by nature, one of slight but of healthy tension. But if constantly overdrawn, or if the tissue of the eye is flabby or not sufficiently resistant, the form is changed so as to become a serious defect. The child that uses the eye too early or too much in study, or with wrong type, or

books, or when the general health is not good, or too soon after recovery from sickness, or in overheated or foul air, or in too great a glare or with deficiency of light, is too likely to give a training to the eye which secures for it more or less imperfection of vision.

24. "Not to refer to the statistics of Germany, the facts given by Loring, Derby, Risley, and Smith, in our own country, show that eye defects are too common among our school-children. Drs. Loring and Derby, in examining 2,265 children in New York City between the ages of six and twenty-one, found, among the youngest, myopia in 3.5 per centum, and among those of older years 26.78 per centum. Dr. Risley of Philadelphia, in an examination of 5,000 eyes, confirms the view as to the frequency of myopia, although also specifying other errors of refraction not included with these. In 400 recent examinations by Dr. Smith of Chicago for the Board of Education, four in every ten were found to have more or less myopia. Professor Erisman says he never knew myopia to begin after the fifteenth or sixteenth year. It generally occurs between six and sixteen years of age, and especially between six and twelve years.

25. "A pupil should be able to see print plainly at a distance of from fourteen to sixteen inches. It is a mistake that short sight improves with advancing years, for although there is, for other reasons, not so early a need of spectacles for far sight, there is a weakening of the posterior eye which subjects it to more accidents after middle life. So Carter says, "Every myopic eye should be looked upon as a weak organ, capable indeed of being preserved in a state of useful-

ness, but liable to many dangers and mischances." Where there is this defect, bi-concave spectacles should be worn, the weakest glass being chosen with which the child can see comfortably. At the same time, effort should be made to overcome the evil, by securing conditions unfavorable to myopia, and by using the eyes briefly without glasses as soon as it can be done without inconvenience, and so soon as a right distance of the book is not found to fatigue, or to give indistinctness.

"It is a great error, because it is wise to resort to glasses, to conclude that all the exciting causes which produced the myopia are to be continued. While we fully recognize the glasses to be the less of two evils, they are not the least, if we accept them as an entire substitute and retain other conditions promotive of myopia. The object of spectacles is not to make the patient see any better, but to compel him to keep his work farther away.

26. **Astigmatism** is that condition of the eye in which all lines running in a given direction look blurred. It has to do with a difference in the curvature of the cornea in two different meridians. It is especially when this is **different** in the two eyes that attention is drawn to it. The correction is made by the use of spectacles having plano-cylindrical lenses. The effects of astigmatism are thus stated by Dr. R. B. Carter: —

"The influence of astigmatism upon the sight is very considerable, and is exerted in various ways. Its first and most obvious effect is to produce differences in the apparent distinctness of equal lines which are drawn in different directions, and in this way it produces indistinctness of some of the linear boundaries

of figures, leaving others clearly defined. Thus, an astigmatic person, in reading a printed page, may be able to see clearly the printed lines which enter into the formation of many letters, and also, for example, distinguish an *m* from an *n*. But he would have to place the page at a different distance, or to alter the accommodation of his eyes, in order to distinguish the horizontal lines with equal clearness, and to tell readily an *n* from *u*.

The indistinctness of many boundary lines produces a corresponding diminution in the acuteness of vision, and the necessity constantly to alter the adjustment in looking at the same object produces great fatigue of the ciliary muscles. Hence defective sight, coupled with weariness and aching of the eyes, are the symptoms of which astigmatic people most commonly complain. These symptoms, which may be kept in comparative abeyance, while the accommodation is strong and active, tend constantly to increase and to become every year more irksome as the accommodation is curtailed by advancing life."

27. In the chapter as to the SCHOOL AND ITS APPOINTMENTS we have already spoken of light in its relation to school-work. A child's eye will not bear the continuous use which older eyes, whose tissue is firm, and whose powers have been developed by habit, may well endure.

Children should not be permitted to read in the evening without good and abundant light. The book should be so placed relatively to the light and the face, that the angle of incidence shall differ from that formed by the book and the eye. The light should never be directly in front of the face. It may be a little to the

left, and in front, but it is better to have it above and behind the head.

No child should be permitted to lie on the floor to study a lesson or read. Especially is this injurious when done before a burning grate. In a recumbent position the strain on the inferior rectus muscle of the eye, or that which moves the eye downward, is very great. The hours given to reading or studying in the evening should be short. The healthy child, who has risen at seven in the morning, and pursued the proper course of study in school through the day, is in no condition, mentally or physically, to resume them again at seven in the evening. If it be necessary, let the evening study be limited to one hour.

28. It is well in reading to interrupt the strain of continuous gaze upon the page, and rest the eyes, by looking into the distance occasionally, even if only for a few seconds. In studying, or in reading anything that requires thought, this is likely to be done unconsciously; the natural condition in close thought is rest of everything except the brain.

As distant vision represents rest for the eyes, and near vision represents exertion, care should be taken in reading not unnecessarily to increase this exertion by holding the book too close. The book should not be held nearer to the eyes than is necessary to make the print appear perfectly sharp and distinct, and no print should be read continuously that cannot be seen clearly at about fifteen inches.

29. In reading while lying down it is hardly possible to hold the book in a favorable position, and the external muscles of the eye are strained. In addition to this,

when the head is on a level with the body, instead of erect, there is a tendency to an excess of blood in the eyes.

"It is not well to persist in reading when overcome with sleep, as there is a constant tendency for the muscles of accommodation to relax, and of the eyes to diverge, and they have to be forced back to their work by an effort of the will. The effect of this is soon shown in a congestion of the blood-vessels of the conjunctiva or white of the eye."

30. Of all the artificial lights, that of an Argand burner is the best, because of its steadiness. That from a good kerosene lamp is next. Candles and the ordinary gas-jets are objectionable, because of flickering; of the latter, the so-called fish-tail burner gives the steadiest flame.

Thus far, care and prevention have applied to the school-room. Too few homes have well-lighted rooms day or night. Even where there are large areas of plate and crystal glass, curtains, lambrequins, and shutters are used to exclude sunlight in the dwellings of the rich; small windows, low rooms, obstructing buildings, and narrow alleys darken the abodes of the poor. The reading of children at home is often done under unfavorable circumstances. Examine the books which come from the library, the story-papers, the novels, the magazines, and the long list of small-type literature. Watch the children, and see the enormous strain they put upon accommodation muscles of the eye to read the abominable print. Compare this with the clear fine face of long primer or pica. The hygienic principles applied to books in school should be enforced in home reading.

The following directions of Dr. Lincoln of Boston are of value: —

31. "When writing, reading, drawing, sewing, always take care that, (*a*) the room is comfortably cool, and the feet warm; (*b*) there is nothing tight about the neck; (*c*) there is plenty of light, without dazzling the eyes; (*d*) the sun does not shine directly upon the object you are at work upon, or upon objects in front of you; (*e*) the light does not come from in front; it is best when it comes over the left shoulder; (*f*) the head is not bent very much over the work; (*g*) the page is nearly perpendicular to the line of sight; that is, that the line of the eye is nearly opposite the middle of the page, for an object held slanting is not seen so clearly; (*h*) that the page or other object is not less than fifteen inches from the eye; (*i*) in any case where the eyes have any defect, fine needlework, drawing of fine maps, and all such work, except for very short tasks in the morning. (*j*) In addition, never study or write before breakfast by lamplight; (*k*) do not lie down when reading; (*l*) if your eyes are aching from firelight, from looking at the snow, from over-work or other causes, a pair of colored glasses may be advised to be used for a while; (*m*) never play tricks with the eyes, as squinting or rolling them. (*n*) The eyes are often troublesome when the stomach is out of order. (*o*) Avoid reading or sewing by twilight, or when debilitated by recent illness, especially fever. (*p*) It is indispensable in all forms of labor requiring the exercise of vision on minute objects, that the worker should rise from his task now and then, take a few deep inspirations with closed mouth; stretch the frame

out into the most erect posture, throw the arms backward and forward, and if possible step to a window, or into the open air, if only for a moment."

32. While the chief danger to children is from **myopia,** or short-sight, there are occasionally children that are **hypermetropic,** or too long-sighted. "Flat-eye" is another name for it. Fatigue, pain, and indistinct vision, after any long reading or study, will be generally complained of. The child does not relieve it by holding the book at a distance, but soon complains again. Headaches and convergent squinting may result from it. Here, **convex glasses are needed.**

Where much reading or writing is done at night, it is well to use a shade over the study-light, so that the light is cast more directly on the paper or book.

33. Persons who see well, and yet are defective in perceiving distinctions of colors, are said to be *color-blind.* This inability is most marked as to red, green, and violet, or blue and violet, which are called the primary colors of the spectrum. Being unable to see these they thus see all colors modified as they would be by their absence. The defect varies greatly in degree. A large proportion of the color-blind are so in reference to *red*, next as to *green*, but comparatively few are violet-blind. A person who is red-blind cannot distinguish red from green. If blind to violet he cannot tell that from yellow. Because systems of color signals, both for ship and railroads, are so indispensable, it is now common to examine employeés as to powers of discerning colors. The usual test is the Holmgren test, which consists in the use of *worsteds* of various colors. The person being examined does not name the colors, but having a sample of each selects and

places each in its appropriate bunch. Examinations show, among men at least, one out of every fifty defective, and many to a degree that unfits them for any service requiring accuracy in the perception of colors. The defect is often congenital, but is also known to be caused by alcohol or tobacco, and by some forms cf mental disease.

34. There are other forms of visual defect, but these are generally so declarative as to excite attention and lead to the seeking of professional advice. As any defect in vision is a serious interference with the work of life, the eye is to be looked upon as the chief instrument of the student, the mechanic, the artisan, the laborer of every kind. As such, it is to be guarded and kept as would be the most essential and delicate tools used in any occupation. To do the best of work with it, it must be kept in the best of order.

It is because this is true to a greater or less extent of every organ, and of the whole body, that the teaching and practice of Hygiene are essential parts of education.

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NOTE.—As all technical terms used are explained in the text, or can be found in the general Dictionaries, it has not been deemed necessary to add a Glossary.